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February 1999

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE

Volume 1 - Defense Advanced Research Projects Agency

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	CCS-02	INFORMATION SCIENCES	16.376	18.627	19.002	19.500	19.700	19.700	20.700	21.700
	ES-01	ELECTRONIC SCIENCES	36.192	20.322	23.124	29.339	29.084	34.645	35.506	36.365
	MS-01	MATERIALS SCIENCES	14.138	25.480	22.167	19.953	21.053	21.053	22.053	23.053
	61101E	**DEFENSE RESEARCH SCIENCES**	**66.706**	**64.429**	**64.293**	**68.792**	**69.837**	**75.398**	**78.259**	**81.118**
62110E	**NGI-01**	**NEXT GENERATION INTERNET**	**39.313**	**49.504**	**40.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	ST-01	JASONS	1.289	1.190	1.200	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	88.691	84.853	79.718	78.341	62.094	69.536	74.393	68.034
	ST-19	HIGH PERFORMANCE AND GLOBAL SCALE SYSTEMS	149.965	163.110	162.900	161.922	169.887	196.265	198.125	200.972
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.609	16.941	17.227	18.100	18.700	19.300	19.300	19.300
	ST-24	INFORMATION SURVIVABILITY	40.092	57.865	61.829	71.460	96.350	99.073	98.930	98.771
	62301E	**COMPUTING SYS & COMM TECHNOLOGY**	**296.646**	**323.959**	**322.874**	**331.023**	**348.231**	**385.374**	**391.948**	**388.277**
62302E	AE-01	DEEPLY NETWORKED SYSTEMS	0.000	0.000	25.000	24.200	12.500	12.000	12.000	12.000
	AE-02	SOFTWARE FOR AUTONOMOUS SYSTEMS	0.000	0.000	27.000	26.300	45.500	48.000	48.000	48.000
	AE-03	SOFTWARE FOR EMBEDDED SYSTEMS	0.000	0.000	18.000	19.500	12.000	10.000	10.000	10.000
	62302E	**EXTENSIBLE INFORMATION SYSTEMS**	**0.000**	**0.000**	**70.000**	**70.000**	**70.000**	**70.000**	**70.000**	**70.000**
62383E	**BW-01**	**BIOLOGICAL WARFARE DEFENSE**	**58.452**	**84.754**	**145.850**	**151.000**	**151.500**	**135.800**	**116.800**	**113.800**
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	17.948	23.100	10.780	7.807	21.140	20.917	20.774	20.615
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	20.330	37.620	39.290	40.321	49.854	54.831	54.688	54.529
	TT-05	ADVANCED TARGETING TECHNOLOGY	0.000	0.000	0.000	0.000	8.400	36.700	46.700	56.700
	TT-06	ADVANCED TACTICAL TECHNOLOGY	53.059	47.859	32.083	20.463	26.968	43.673	43.530	43.371
	TT-07	AERONAUTICS TECHNOLOGY	19.185	30.694	35.385	35.346	39.168	39.593	45.450	49.291
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	20.685	20.853	10.352	10.000	16.800	16.800	16.800	16.800
	TT-11	JOINT LOGISTICS	9.790	9.633	9.736	10.000	10.000	0.000	0.000	0.000
	62702E	**TACTICAL TECHNOLOGY**	**140.997**	**169.759**	**137.626**	**123.937**	**172.330**	**212.514**	**227.942**	**241.306**
62708E	**IC-03**	**INTERGRATED COMMAND & CONTROL TECH**	**43.994**	**39.607**	**31.296**	**32.000**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	123.603	169.416	111.419	126.512	135.523	135.972	141.054	150.895
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	60.972	87.801	97.356	71.216	60.594	63.358	73.215	83.056
	MPT-06	CRYOGENIC ELECTRONICS	17.549	18.164	26.546	21.335	15.168	9.945	9.802	9.643
	MPT-07	MILITARY MEDICAL/TRAUMA CARE TECHNOLOGY	11.262	2.905	0.000	0.000	0.000	0.000	0.000	0.000
	62712E	**MATERIALS & ELECTRONICS TECHNOLOGY**	**213.386**	**278.286**	**235.321**	**219.063**	**211.285**	**209.275**	**224.071**	**243.594**
63285E	**ASP-01**	**ADVANCED AEROSPACE SYSTEMS**	**0.000**	**0.000**	**19.664**	**19.000**	**23.000**	**5.000**	**5.986**	**9.986**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63739E	MT-03	UNCOOLED INTEGRATED SENSORS	8.289	12.895	10.791	12.000	7.000	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	65.515	62.985	56.686	41.245	40.849	59.667	63.029	64.829
	MT-05	TACTICAL INFORMATION SYSTEMS	28.328	30.998	15.605	17.748	18.100	0.000	0.000	0.000
	MT-06	MICROWAVE & ANALOG FRONT END TECHNOLOGY	17.543	3.962	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	5.904	6.405	4.000	0.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPLICATIONS	26.175	21.991	21.846	4.000	6.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	49.710	49.362	44.429	45.000	45.000	45.000	45.000	45.000
	MT-12	MEMS	70.556	76.844	70.098	63.350	70.575	93.100	101.325	98.325
	MT-15	MIXED TECHNOLOGY INTEGRATION	0.000	0.000	22.568	49.855	45.010	50.000	50.000	50.000
	63739E	**ADVANCED ELECTRONICS TECHNOLOGY**	**272.020**	**265.442**	**246.023**	**233.198**	**232.534**	**247.767**	**259.354**	**258.154**
63746E	**MR-01**	**MARITIME TECHNOLOGY**	**32.750**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63747E	**EV-01**	**ELECTRIC VEHICLES**	**15.000**	**9.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYSTEMS	65.219	86.596	109.933	109.834	94.734	93.734	104.034	104.834
	CCC-02	INFORMATION INTEGRATION SYSTEMS	82.306	90.896	112.955	103.546	115.749	105.746	115.012	113.837
	63760E	**COMMAND, CONT'L & COMMUNICATIONS SYS**	**147.525**	**177.492**	**222.888**	**213.380**	**210.483**	**199.480**	**219.046**	**218.671**
63761E	CST-01	ADVANCED SIMULATION	29.050	26.397	0.000	0.000	0.000	0.000	0.000	0.000
	CST-02	GLOBAL GRID COMMUNICATIONS	38.519	25.861	0.000	0.000	0.000	0.000	0.000	0.000
	CST-03	DEFENSE SIMULATION INTERNET (DSI)	2.596	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	63761E	**COMMUNICATION & SIMULATION TECH**	**70.165**	**52.258**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63762E	SGT-01	GUIDANCE TECHNOLOGY	35.275	34.189	19.666	12.231	22.633	32.964	33.764	36.564
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGIES	19.999	65.899	71.012	70.229	73.517	90.686	77.500	84.300
	SGT-03	AIR DEFENSE INITIATIVE	20.170	25.257	40.350	38.680	35.460	35.000	38.000	38.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	85.437	84.626	101.291	90.753	104.976	92.832	92.832	92.832
	63762E	**SENSOR & GUIDANCE TECHNOLOGY**	**160.881**	**209.971**	**232.319**	**211.893**	**236.586**	**251.482**	**242.096**	**251.896**
63763E	**MRN-02**	**MARINE TECHNOLOGY**	**19.597**	**23.659**	**22.538**	**21.964**	**48.396**	**55.896**	**57.696**	**60.496**
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY	40.304	44.991	50.223	50.176	63.177	27.000	22.000	22.000
	LNW-02	SMALL UNIT OPERATIONS	39.015	43.622	47.602	51.200	43.500	50.000	65.000	65.000
	63764E	**LAND WARFARE TECHNOLOGY**	**79.319**	**88.613**	**97.825**	**101.376**	**106.677**	**77.000**	**87.000**	**87.000**
63765E	**CLP-01**	**CLASSIFIED**	**124.194**	**50.040**	**77.780**	**49.600**	**19.100**	**13.100**	**0.000**	**0.000**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63800E	JA-01	JOINT STRIKE FIGHTER PROGRAM	21.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63805E	GC-01	DUAL USE APPLICATIONS PROGRAMS	115.784	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65114E	BL-01	BLACKLITE	4.522	4.985	5.000	5.000	5.000	5.000	5.000	5.000
65502E	SB-01	SMALL BUSINESS	45.869	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65898E	MH-01	MANAGEMENT HEADQUARTERS (R&D)	35.633	38.498	31.387	32.632	33.944	35.373	36.634	36.922
99999E	CA-01	CANCELLED ACCOUNTS	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AGENCY TOTAL		2,004.033	1,930.256	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
	BA-01	TOTAL	66.706	64.429	64.293	68.792	69.837	75.398	78.259	81.118
	BA-02	TOTAL	792.788	945.869	982.967	927.023	953.346	1,012.963	1,030.761	1,056.977
	BA-03	TOTAL	1,058.369	876.475	919.037	850.411	876.776	849.725	871.178	886.203
	BA-06	TOTAL	86.170	43.483	36.387	37.632	38.944	40.373	41.634	41.922
	AGENCY TOTAL		2,004.033	1,930.256	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R1 #2					
COST (*In Millions*)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	66.706	64.429	64.293	68.792	69.837	75.398	78.259	81.118	Continuing	Continuing
Information Sciences CCS-02	16.376	18.627	19.002	19.500	19.700	19.700	20.700	21.700	Continuing	Continuing
Electronic Sciences ES-01	36.192	20.322	23.124	29.339	29.084	34.645	35.506	36.365	Continuing	Continuing
Materials Sciences MS-01	14.138	25.480	22.167	19.953	21.053	21.053	22.053	23.053	Continuing	Continuing

(U) **Mission Description:**

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.

(U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as computational models, Quantum Computing, biological computing and human-language systems.

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; advanced thermoelectric materials for cooling and power generation; and novel propulsion concepts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(U) **Program Change Summary:** (*In Millions*)

	FY 1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	68.332	65.102	65.400	70.036
Current Budget	66.706	64.429	64.293	68.792

(U) **Change Summary Explanation:**

FY 1998	Decrease reflects SBIR reprogramming and minor realignment of program priorities.
FY 1999	Decrease reflects reductions associated with Congressional adjustments.
FY 2000/01	Decreases reflect reductions associated with lower projected inflation rates.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Information Sciences CCS-02	16.376	18.627	19.002	19.500	19.700	19.700	20.700	21.700	Continuing	Continuing

(U) **Mission Description:**

(U) This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as computational models and new mechanisms for performing computation and communication involving quantum physics, biological and optical processes. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) In the area of quantum computing, the project will identify and probe new classes of computing technologies, which may offer spectacular performance/cost/size/weight/power improvements beyond the ultimate limitations of today's semiconductor-based computing. Quantum logic, based on subatomic scale physical phenomena, could enable a tremendous leap in computational capacity. However, a number of significant hurdles, including the development of sequencing mechanisms, large scale storage, input/output channels and quantum-enabled approaches to algorithms and error correction must be overcome.

(U) In the area of biological computing, the project will support the scientific study and experimentation that is at the interface of information technology and biological technology, with emphasis on biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes.

(U) In the area of optical communication and computing, the project will explore new approaches to transmission based on solitons and identify novel buffering technologies that can be substituted for optical delay lines.

(U) In the areas of software engineering, the project will investigate formal techniques for the construction of safety critical systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) In the area of human computer interfaces the project will study information management, interface technologies and their relationship to cognitive processes.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Investigated computational models suitable for implementation using Quantum computing techniques. ($ 5.681 Million)
- Developed architecture for low-power configurable computational elements. ($ 1.303 Million)
- Prototyped robust spoken and text language technologies with emphasis on affordable grammars and understanding. ($ 7.479 Million)
- Evaluated quality of service specifications; demonstrated real-time adaptive control and resource management; released version of defense-critical software based on scalable library technology. ($ 1.913 Million)

(U) **FY 1999 Plans:**

- Demonstrate and validate computing models, with emphasis on: DNA-based logic operations and cell-based computation. ($ 4.410 Million)
- Investigate novel control mechanisms for self-organizing and autonomous systems. ($ 2.779 Million)
- Demonstrate human-computer interaction for crisis planning. ($ 3.690 Million)
- Investigate feedback-driven approaches to information management. ($ 6.241 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Validate low-power configurable architecture; develop supporting software; and demonstrate automated mapping of 500K elements. ($ 1.507 Million)

(U) **FY 2000 Plans:**

- Biological Computing. ($ 5.902 Million)
  - Evaluate alternative approaches to DNA-based computing and identify the most promising research opportunities for enhancement and acceleration.
  - Explore mechanisms for sequencing of DNA-based computations.
  - Investigate novel approaches to real-time biological instrumentation in support of interactive biology.
- Quantum and Optical Computing. ($ 4.000 Million)
  - Develop new algorithms for quantum-enabled computation.
  - Design sequencing and input/output mechanisms for quantum computing.
  - Identify alternative optical buffering technologies.
- Software Engineering and Human Computer Interface. ($ 9.100 Million)
  - Investigate design of domain specific languages for use in safety critical systems.
  - Investigate machine translation and relevance of new results in cognitive science research to spoken language and haptic interfaces.

(U) **FY 2001 Plans:**

- Biological Computing. ($ 6.900 Million)
  - Prototype demonstration of robot control sequencing of DNA-based computations.
  - Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Quantum and Optical Computing. ($ 4.000 Million)
  - Simulate new algorithms for quantum-enabled computation and evaluate potential speed-up over conventional methods.
  - Prototype demonstration of sequencing and input/output mechanisms enabling quantum computing.
  - Laboratory demonstration of soliton-based packet multiplexing, incorporating optical buffering.

- Software Engineering and Human Computer Interface. ($ 8.600 Million)
  - Develop formal methods to support domain specific languages for use in safety critical systems.
  - Investigate interface technologies to facilitate the tasking and management of autonomous systems.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Electronic Sciences ES-01	36.192	20.322	23.124	29.339	29.084	34.645	35.506	36.365	Continuing	Continuing

(U) **Mission Description:**

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) This project is also concerned with coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components critical to enhancing the effectiveness of military platforms that enable warfighter capabilities for comprehensive awareness and precision engagement and contribute to the continued advancement of Next Generation Internet capabilities. Topics to be researched include emitters, detectors, modulators and switches operating from infrared to ultra violet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Optoelectronics - Demonstrated feasibility of using Gallium Nitride detectors as a UV solar-blind detector for missile threat warning and demonstrated UV/blue lasers operating continuous wave for high-density memory and chemical/biological detection. ($ 9.200 Million)
- Infrared Detector Materials - Determined process for low temperature deposition of thin film uncooled materials. ($ 2.600 Million)
- UltraElectronics - Demonstrated feasibility of combining a resonant tunneling device (RTD) with conventional devices, silicon based quantum metal oxide semiconductor (MOS) technology and simple quantum cellular automatic logic circuits using silicon and silicon germanium structures. ($ 10.000 Million)
- UltraPhotonics - Demonstrated practical means for implementing high speed optical buffer memories and signal address recognition based on coherent, all-optical (photon-echo) technology. Demonstrated the utility of low cost silicon electronic devices doped with optically active elements (such as Erbium) for applications that were the exclusive domain of more expensive compound semiconductor devices or glassy materials. ($ 9.000 Million)
- Low Power Electronics - Completed low-power electronics programs in the areas of circuit architecture and power management techniques. Demonstrated 256 x 256 pixel image sensor with on-chip, 10-bit Analog-Digital Converter. ($ 5.392 Million)

(U) **FY 1999 Plans:**

- Infrared Detector Materials - Establish feasibility of new uncooled detector structures, including micromachined arrays, thin film ferroelectrics and bolometric materials. ($ 2.861 Million)
- UltraElectronics - Demonstrate programmable matched filter operating at gigahertz speed with substantially less power than silicon complimentary metal oxide semiconductor (Si CMOS), completely integrated molecular beam epitaxy (MBE) growth system that realizes closed-loop control of atomic layer growth and quantum device structures. ($ 4.641 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- UltraPhotonics - Identify the device properties limiting performance of vertical cavity lasers and demonstrate methods for controlling their output beam quality. ($ 7.378 Million)
- Integrate promising new elements of ultraelectronics, high power electronics, non-volatile memory and Electro-Magnetic Interference (EMI) electronics. Address, evaluate and apply current EMI thrusts in smaller, lighter, more mobile information systems and highest performance components and systems. ($ 2.389 Million)
- Initiate mechanical electronics development resulting in very high efficiency DC-DC converters. ($ 0.954 Million)
- Terahertz Technology - Explore technologies for a region of the electromagnetic spectrum (300Ghz to 10Thz, 1mm to 30 micrometer) that has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery and covert satellite communications. ($ 2.099 Million)

(U) **FY 2000 Plans:**

- Mechanical Electronics - Demonstrate the properties for mechanical switches that include device speed and current density scale and size, hysteretic behavior for non-volatile memory applications and reduce the threshold switching voltage to below 10V. ($ 1.898 Million)
- Terahertz Technology - Continue to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation and investigate the feasibility of integrating these components to form a range of compact subsystems for applications in space based communications, remote sensing, collision avoidance radar and covert communications. ($ 3.416 Million)
- Microinstruments – Research new technology for diagnostic instruments to support, maintain and service the warfighter and military platforms. Investigate new technology concepts that support high volume/low cost wearable and hand-held diagnostic instruments. Microinstruments "on-a-chip" concepts that integrate sensors, electronics, storage, display and actuation are the goals of this research. Microinstruments that include fluid dispensing and fluid sensing and fluid identification are important for "in-the-field" medical, chemical/biological and equipment diagnostics and repair. ($ 9.810 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- Establish university centers of excellence in optoelectronic engineering research and identify methods for transitioning research results to industry. ($ 8.000 Million)

(U) **FY 2001 Plans:**

- Terahertz Technology - Demonstrate, for the terahertz spectral region, the best semiconductor quantum-well approaches to sources, demonstrate semiconductor quantum-well detectors and identify system requirements to achieve space communications, upper-atmosphere imagery and close-operations covert communications. ($ 3.800 Million)

- Microinstruments - Demonstrate a patterning microinstrument that writes a pattern of array of 50nm minimum - feature-size (MFS) bits or pixels at a rate of $6cm^2$/sec over an area of $1cm^2$. Demonstrate fluidic patterning of pixels 20nm x 20nm over a 1mm x 1mm area using a microinstrument "on-a-chip". Demonstrate an array of 10,000 probes for imaging 10nm defects, electrical pads or bits on an integrated circuit. Demonstrate non-destructive controlled manipulation of cells. ($ 13.539 Million)

- Demonstrate methods for materials processing for the integration of heterogeneous materials to realize innovative optoelectronic modules for sensing and communicating. ($ 12.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Materials Sciences MS-01	14.138	25.480	22.167	19.953	21.053	21.053	22.053	23.053	Continuing	Continuing

(U) **Mission Description:**

(U) This project is concerned with fundamental research leading to the development of high power density/high energy density mobile and portable power sources, advanced thermoelectric materials for cooling and power generation, processing and design approaches for nanoscale and/or biomolecular materials and interfaces, materials and measurements for molecular-scale electronics, medical pathogen countermeasures and novel methods for reducing drag in future generations of high-speed ships.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Electrochemistry. ($ 8.511 Million)
  - Constructed and tested a logistics fueled fuel cell power plant for mobile electric power applications.
  - Began component and system study/demonstration of a direct oxidation fuel cell for replacement of military standard batteries.
  - Explored alternative sources of energy for portable power applications (for example, piezoelectric materials).
  - Developed and demonstrated thermophotovoltaic materials with significantly improved performance.
- Nanoscale/Biomolecular Materials. ($ 1.350 Million)
  - Exploited recent advances in materials design and processing to demonstrate nanostructural control of materials properties with an emphasis on emulating the complex microstructure and scale of biological materials.
- Pathogen Countermeasures. ($ 2.477 Million)
  - Determined one or more mechanisms a stem cell could use to link the detection of a pathogen to the production by the cell of vaccines and/or therapeutics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Thermoelectric Materials. ($ 1.800 Million)
  - Demonstrated materials with a factor of two increase in the thermoelectric figure of merit.

(U) **FY 1999 Plans:**

- Portable Power. ($ 9.391 Million)
  - Optimize catalysts, membranes and separator plates for high energy density solid oxide and direct methanol fuel cells.
  - Brassboard testing of compact, high performance 500W solid oxide fuel cells for portable power applications.
  - Demonstrate novel 500W thermophotovoltaic power sources based on advanced materials.
- Nanoscale/Biomolecular Materials. ($ 6.300 Million)
  - Demonstrate the applicability of nanostructural materials in defense applications such as armor, high strength fibers, coatings or electronics.
  - Explore novel concepts in biomolecular materials and interfaces.
  - Develop single molecules and/or nanoparticles that exhibit electronic functionality and measure their intrinsic electronic properties.
- Pathogen Countermeasures. ($ 5.189 Million)
  - Determine mechanisms of disease causing (virulence) factors in pathogens of concern to the DoD.
- Thermoelectric Materials. ($ 3.712 Million)
  - Develop thin film cooler utilizing quantum well structures.
- Fast Ship. ($ 0.888 Million)
  - Initiate a study to explore the underlying physics and the effects of material shaping on hydrodynamic drag reduction.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **FY 2000 Plans:**

- Portable Power. ($ 5.000 Million)
  - Design, build and test portable power systems that operate directly on logistics fuels.
  - Demonstrate an integrated 50W proton exchange membrane fuel cell operating on several novel hydrogen sources.
  - Demonstrate a portable, packaged direct methanol fuel cell.
- Nanoscale/Biomolecular Materials. ($ 7.167 Million)
  - Explore novel processing schemes for the formation of nanoscale/biomolecular materials and interfaces.
  - Explore the capabilities of quasicrystals, carbon nanotubes and other nanostructured materials for enhancing structural and functional performance of defense systems.
  - Establish focused basic research initiatives in biomimetics and other bioengineering disciplines to foster creative interdisciplinary research in biology and engineering and to ensure this critical technical area is responsive to future defense needs.
- Molecular Electronics. ($ 7.000 Million)
  - Demonstrate that two interconnected molecules and/or nanoparticles show the anticipated functionality.
  - Demonstrate the ability to reversibly and repeatably transfer information from one molecule or nanoparticle to another.
  - Demonstrate that molecular and/or nanostructured materials can perform a storage function that can be driven from one state to another by an external signal.
- Fast Ship. ($ 3.000 Million)
  - Explore novel methods of drag reduction (i.e., the use of air injection).
  - Design and build a small scale, high-speed model for micro bubble air flow testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **FY 2001 Plans:**

- Nanoscale/Biomolecular Materials. ($ 6.953 Million)
  - Demonstrate enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrate the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular materials and structures.
  - Continue interdisciplinary basic research initiatives in biomimetics/bioengineering and begin exploration of potential defense applications.

- Molecular Electronics. ($ 9.000 Million)
  - Demonstrate that molecules and/or nanoparticles can self-assemble into functional, regular patterns forming a molecular memory.
  - Demonstrate assembly architectures that enable interconnected molecules and/or nanostructures to function even though some of the molecular components are defective.

- Fast Ship. ($ 4.000 Million)
  - Perform design trade studies, test and evaluate drag reduction technologies using small scale models, estimate resulting performance and determine the scalability of model-based results to full-size vessels.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E, R-1 #7					
COST *(In Millions)*	FY1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	39.313	49.504	40.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
Next Generation Internet NGI-01	39.313	49.504	40.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

(U) **Mission Description:**

(U) The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in an NGI developed testbed environment.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Designed and initiated implementation of the NGI testbed. ($ 7.313 Million)
- Created ultra high bandwidth Wavelength Division Multiplexed (WDM) connections for Next Generation Internet (NGI) testbed (Supernet). ($ 15.000 Million)
- Developed NGI quality of service architecture and implemented initial operating system services. ($ 15.000 Million)
- Executed Congressionally mandated add to the NGI program. ($ 2.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

(U) **FY 1999 Plans:**

- Implement 10 gigabit-per-second, multi-wave optically switched Wavelength Division Multiplexed (WDM) technology in NGI testbed. ($ 5.100 Million)
- Implement an alpha-level prototype high-speed optical multiplexor and develop specification of Internet Protocol (IP)/WDM protocol structure. ($ 11.300 Million)
- Expand testbed to DoD supported laboratories and to 10 gigabit-per-second links. ($ 5.304 Million)
- Implement prototype components of network monitoring and management system. ($ 7.900 Million)
- Define application program interfaces for information management and collaborative applications. ($ 4.900 Million)
- Execute Congressionally mandated partnerships between centers with supercomputers purchased with DoD RDT&E funds and DoD Major Shared Resource Centers. ($ 5.000 Million)
- Execute Congressionally mandated regional partnerships for revolutionary applications. ($ 10.000 Million)

(U) **FY 2000 Plans:**

- Implement variable rate access technologies and prototype of distributed optical switching capability compatible with 100 Gb/s optical network. ($ 6.000 Million)
- Implement streamlined Internet over WDM protocol structure, eliminating two layers of existing telecommunications infrastructure. ($ 11.000 Million)
- Develop network planning and simulation technology to meet requirements for NGI scale networks. ($ 5.500 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

- Demonstrate real-time (500-msec response) monitoring and control of network resources at all levels. ($ 3.500 Million)
- Complete interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity. ($ 9.000 Million)
- Demonstrate information management and collaborative applications operating over NGI testbed. ($ 5.000 Million)

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Program Change Summary:** (*In Millions*)

	FY 1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	40.453	40.000	40.000	0.000
Current Budget	39.313	49.504	40.000	0.000

(U) **Change Summary Explanation:**

FY 1998 Decrease results from minor program repricing and SBIR reprogramming.

FY 1999 Increase due to Congressionally mandated partnership programs, less undistributed reductions mandated by the Appropriations Act and applied on a pro rata basis.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, R-1 #12					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	296.646	323.959	322.874	331.023	348.231	385.374	391.948	388.277	Continuing	Continuing
JASON ST-01	1.289	1.190	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing
Intelligent Systems and Software ST-11	88.691	84.853	79.718	78.341	62.094	69.536	74.393	68.034	Continuing	Continuing
High Performance and Global Scale Systems ST-19	149.965	163.110	162.900	161.922	169.887	196.265	198.125	200.972	Continuing	Continuing
Software Engineering Technology ST-22	16.609	16.941	17.227	18.100	18.700	19.300	19.300	19.300	Continuing	Continuing
Information Survivability ST-24	40.092	57.865	61.829	71.460	96.350	99.073	98.930	98.771	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The JASON Group supports studies for the national security community.

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software intensive defense systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E

(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The Software Engineering Technology project supports the Software Engineering Institute (SEI) whose mission is to transition state-of-the-art technology, and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems.

(U) The Information Survivability project develops the technology base underlying the solutions to protecting DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites and to high-performance computing technologies.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	309.037	417.723	368.779	412.248
Current Budget	296.646	323.959	322.874	331.023

(U) **Change Summary Explanation:**

FY 1998 Decrease reflected accelerated completion of the Human Computer Interaction effort stand-alone program and integration of the related technologies into other intelligent systems programs, and SBIR reprogramming.

FY 1999 Decrease reflects the net effect of congressional program and undistributed reductions. Congress eliminated funding for the Joint Infrastructure Protection program and the Hands-Free Interface program as well as halved the funding for the networking effort.

FY 2000-2001 Decrease reflects discontinuance of Adaptive Computing and Software Composition programs, and program restructuring and reprioritization in Defense Technology Integration and Data Intensive Systems and Software programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communication Technology PE 0602301E, Project ST-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
JASON ST-01	1.289	1.190	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project supports the JASONs, an independent group of distinguished scientists and technical researchers that provides analysis of critical national security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, and other allied disciplines. The JASON process ensures senior government leaders have the full range of U.S. academic expertise available on issues critical to national security involving classified and unclassified information.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Continued studies in: counter proliferation of chemical and biological weapons; advanced sensors to support small unit operations; high bandwidth urban communications; characterization of underground facilities; novel energetic materials; small scale propulsion; and land mine detection. ($ 1.289 Million)

(U) **FY 1999 Plans:**

- Continue studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; advanced sensor technologies; advanced computing; land mine detection; battlefield information systems; battlefield planning and control; small unit operations; military communications; and novel materials. ($ 1.190 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communication Technology PE 0602301E, Project ST-01

(U) **FY 2000 Plans:**

- Continue studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self monitoring materials. ($ 1.200 Million)

(U) **FY 2001 Plans:**

- Continue studies of interest to DoD. ($ 1.200 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	88.691	84.853	79.718	78.341	62.094	69.536	74.393	68.034	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

(U) Major areas of technical emphasis are: (a) sensor data processing that leverages software-based intelligent processing to acquire sensory information, including advanced airborne video data; (b) situation analysis that provides for the intelligent integration of information from heterogeneous sources, including advanced airborne video data; interactive problem solving, planning, scheduling and decision analysis; and rapid development of large knowledge bases; (c) situation presentation technologies that provide intelligent interfaces to the resultant information streams, including the integration and application of emerging language understanding and translation to address both C4I and intelligence community needs; and (d) information interoperability technologies to support enhanced effectiveness of multi-national missions.

(U) As this program matures, it will have a reduced emphasis on software composition, i.e., the methodology and tools used to compose intelligent software. Beginning in FY 2000, there will be an increased emphasis on the development of intelligent applications that leverage the composition tools developed in the earlier phase of the project. Specific domains of interest are situation analysis, situation presentation, and the processing of sensor-derived information.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project Intelligent Systems and Software ST-11

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Software Composition. ($ 30.052 Million)
  - Integrated selected Rapid Design Exploration and Optimization (RaDEO) designed computation tools that demonstrate robust multi-disciplinary design. Demonstrated a 5X reduction in early design trade-off time by combining qualitative & quantitative models.
  - Released design of Formal Language for Expressing Assumptions.
  - Released Version 2 of core architectural description interchange language (ACME) and demonstrated use of ACME to represent multiple domain-specific software models.
  - Released real-time dynamic language system for use by Integrated Feasibility Demonstration teams.
  - Completed Computer Aided Education and Training Instruction (CAETI) effort to enhance training environments.

- Active Sensors. ($ 22.258 Million)
  - Developed, demonstrated, and evaluated image understanding technologies for image exploitation, automatic population of geospatial database, video surveillance and monitoring, and automatic target recognition to enhance battlefield awareness.
  - Developed concept of operations for Airborne Video Surveillance (AVS) system in cooperation with government video surveillance users. Developed AVS detailed system design and multi-year technology build/evaluate plan. Collected ground truthed data of events and moving targets at the Fort A.P. Hill experimental site and used this data for late FY 1998 laboratory demonstrations of precision video registration (PVR), activity monitoring (AM), and moving target surveillance (MTS) technology.
  - Supported software initiatives at the National Applied Software Engineering Center (NASEC); Johnstown, PA.

- Situation Analysis. ($ 36.381 Million)
  - Developed initial prototypes for multi-language text extraction and audio transcription where performance is baselined against that of human operators.
  - Continued development of modular Human Language Technologies to support easy, low-cost, rapid technology transfer and application development for Document Understanding, Machine Translation, and Speech Understanding.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Integrated human-in-the-loop, automated planning, and decision aids techniques for managing military command and control processes in quickly-changing operational settings; demonstrated capabilities to generate, assess, and select among multiple alternative plans in the same amount of time currently required to generate one plan.
- Used unified ontologies in tools for focused knowledge acquisition; extended learning methods; and added new high-performance, problem-solving methods to the High Performance Knowledge Base library for battlefield awareness, crisis management, and military command and control.
- Developed, in the Intelligent Integration of Information area, tools and techniques to enable the rapid construction of information fusion, aggregation, and summarization software to filter, access, and integrate information from hundreds of disparate, heterogenous, distributed data sources.
- Executed congressionally mandated Reuse Technology Adoption Program (RTAP).

(U) **FY 1999 Plans:**

- Software Composition. ($ 23.134 Million)
  - Conduct Instrumented Feasibility Demonstration (IFDs) of evolutionary design technologies; IFD participants include USTRANSCOM, Joint STARS, and B2 software maintenance.
  - Investigate active approaches to software composition, with emphasis on aspect-oriented programming; on-the-fly component generation and interconnection; and module self-evaluation and configuration.
  - Demonstrate a 2X reduction in detailed design by integrating Design Web and Computational Tools made for multi-disciplinary optimization.
  - Demonstrate web-based toolkit of representation, analysis and generation tools.
- Active Sensors. ($ 26.993 Million)
  - Integrate the most successful new image understanding and automatic target recognition technologies into feasibility demonstrations for video image exploitation, synthetic environments, and video surveillance; demonstrate and evaluate impact of embedded image understanding technologies on battlefield awareness.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Integrate, demonstrate and evaluate laboratory and airborne systems in a simulated cantonment area monitoring scenario, with these technology goals: Activity Monitoring - detect soldier incursion and removal of restricted vehicles from a small area or point; Moving Target Surveillance - maintain track on the removed vehicles, with reliable target re-acquisition as the sensor is multiplexed and tracks are occluded by trees; Precision Video Registration - geolocate moving and stationary vehicles in 80% of the video sequences within 5-10 meters of ground truth.
- Initiate Image Understanding for Force Protection program to demonstrate application of sensor technologies to the difficult task of automated perimeter security.

• Situation Analysis and Presentation. ($ 34.726 Million)

- Develop language comprehension technology to provide extraction of content and production of summary information focused on information access, manipulation and creation tasks in order to demonstrate improved readiness for military planning and situation awareness.
- Develop and demonstrate fully automatic algorithms to determine the structure of radio and TV news broadcasts in several languages allowing military planners and intelligence analysts to detect and track emerging topics.
- Develop and demonstrate a large, integrated situation assessment knowledge base through reuse of knowledge base components from heterogeneous sources.
- Define a million axiom knowledge base construction problem and competency test for a military challenge problem requiring technical, military strategy and tactics, and geopolitical knowledge.
- Demonstrate the utility of man-machine planning and execution control against an aggressive adversary in a realistic simulation of an operational environment and transition to applications and systems programs.
- Demonstrate and transition Intelligent Integration of Information tools and techniques to enable the rapid construction of large-scale information associates to filter, access, and integrate information from 100s of disparate, heterogenous data sources.
- Execute Congressionally mandated Asset Source for Software Engineering Technology (ASSET) program.
- Execute Congressionally mandated program in multi-spectral imaging.
- Execute Congressionally mandated Reuse Technology Adoption Program (RTAP).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

(U) **FY 2000 Plans:**

- Intelligent Sensor Processing. ($ 20.482 Million)
  - Develop fully automated video sentries detecting and tracking a skilled infantry squad attempting ingress to a built up site from wooded, grassy, and open terrain over a 24 hour period using an array of cooperating visual and thermal sensors.
  - Specify challenge scenarios, metrics and measurement techniques for competitive evaluation of multi-modal acquisition technologies.
  - Continue development of the Image Understanding for Force Protection (IUFP) program.
- Situation Analysis. ($ 26.736 Million)
  - Demonstrate statistically based semantic analysis capabilities across four repositories, at least one of which supports access controls.
  - Develop component theory building technologies enabling direct knowledge entry by artificial intelligence novices.
- Situation Presentation and Interaction. ($ 20.000 Million)
  - Specify network-based service architecture Application Program Interface's (API's) for key components of dialogue architecture; using metrics-based evaluation, demonstrate usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80 percent.
  - Demonstrate language and diagram interface, analogic reasoners, and theory explanation capabilities, as well as, develop 10-20 core theories (5K-10K axioms each).
- Intelligent Software for Multi-lingual and Coalition Environments. ($ 12.500 Million)
  - Demonstrate translingual document clustering for representative European and Asian languages.
  - Field demonstration of automated translation of briefing documents during U.S. exercises in Republic of Korea.

(U) **FY 2001 Plans:**

- Intelligent Sensor Processing. ($ 14.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Demonstrate, via the IUFP program, real-time detection of anomalous behavior in streets and indoor scenes by a cooperating sensor array to be followed by tracking targeted subjects with high resolution sensors for automated comparison with a catalog of known subjects. Detection and tracking performed regardless of weather or illumination; identified intruders are tracked and reported using site model plan and 3D displays.

- Situation Analysis. ($ 29.200 Million)
  - Deploy scalable prototype analysis environment in defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value filtering, user defined alerting, and categorizing).
  - Demonstrate direct knowledge entry by a novice (2K axioms/month) for a military problem.

- Situation Presentation and Interaction. ($ 20.000 Million)
  - Engineering integration of key components of dialogue architecture.
  - Demonstrate and evaluate dialogue performance for Project Marine; complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.
  - Alpha level prototype of modality coordinator for speech, gestures and mouse interactions.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 15.141 Million)
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.
  - Prototype implementation of coalition intelligence integration capability demonstrating synthesis of feedback-based approach to query processing with machine translation.

(U) **Other Program Funding Summary Cost:**

Not Applicable.

(U) **Schedule Profile:**

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	149.965	163.110	162.900	161.922	169.887	196.265	198.125	200.972	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of the following components:

- The Global Mobile Information Systems effort will enable mobile users to access and utilize the full range of services available in the Defense Information Infrastructure. To achieve this goal, it will develop nomadic technologies and techniques at the applications, networking, and wireless link/node levels.

- The Networking component develops active networking technologies and associated network management capabilities to support deeply networked systems. Research is coordinated with DoD, NASA, DoE, NSF, and other federal agencies.

- The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.

- The Adaptive Architectures component develops new approaches to the design of computer hardware that incorporates dynamic configuration capabilities. The resultant devices will allow DoD to develop a wide variety of specialized systems by reusing a relatively small set of hardware designs, each of which can be affordably produced in high volumes.

- The Systems Environments component develops scalable software which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications.

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- The Signal Processing component is developing software and component level technologies for use in embedded systems that leverage novel signal processing technologies.

- The Defense Technology Integration component is demonstrating new system capabilities that emerge through the integration of selected technologies developed within this program element.

- Each of the above components of this program will integrate capabilities developed under the Information Survivability initiative (Project ST-24) to satisfy defense requirements for secure systems.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Global Mobile Information Systems. ($ 14.833 Million)
  - Demonstrated middleware services for adapting applications to changing infrastructure resources.
  - Developed advanced algorithms and components for waveform processing at untethered nodes.
  - Developed software modules for reconfigurable radios.
  - Conducted integrated technology demonstrations.

- Networking. ($ 20.548 Million)
  - Implemented prototypes of Enhanced Networking Services utilizing composable modules.
  - Completed prototype implementation of active node execution environment; of fast compiler for SmartPacket Methods; and of basic management functions.
  - Initiated operation of wide area Active Network on prototype platforms.

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- Scalable Systems and Software. ($ 30.916 Million)
  - Scalable Computing.
    - Demonstrated highly efficient, parallel nodes; auto-parallelization of file input/output (I/O) for scalable systems; first node-level performance of ultra-low-power systems; and distributed, shared-memory support for a commodity processor.
  - Ultrascale Computing.
    - Assessed quantum-to-Si hardware and software interface; and language for expressing amorphous algorithmic computations.
  - Scalable Software.
    - Demonstrated fault-tolerant allocation of 100K-entity synthetic force simulation on 1,300 nodes spanning 13 machines at 9 sites.

- Microsystems. ($ 28.193 Million)
  - Demonstrated formal methods for microprocessor verification.
  - Demonstrated integrated environment for design of advanced microcomponents.
  - Developed novel subsystem designs that use configurable component technology.
  - Demonstrated adaptive template matching concept through software prototype capable of automated runtime remapping.

- Embeddable Computing. ($ 14.607 Million)
  - Completed prototype suitable for demonstration of embeddable computing technology in unmanned undersea vehicle (UUV) real-time testbeds.
  - Proof of concept demonstration of Microelectromechanical Systems (MEMS) based thermal dissipation device for use in high-density Digital Signal Processing (DSP) packaging capable of achieving 1 TFlop/cu. ft.
  - Released initial versions of space-time adaptive processing (STAP) algorithm tools and libraries.
  - Developed domain-specific development tools with visualization capability and MatLab compatible system generator.

- Systems Environments. ($ 15.873 Million)
  - Demonstrated experimental versions of new iterative solvers for radar cross-section modeling; languages and runtime services supporting parallel applications such as Advanced Distributed Simulation; and HPC++ languages and runtime services supporting both task and data parallelism.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Defense Technology Integration and Infrastructure. ($ 24.995 Million)
  - Information Management.
    - Developed algorithms to effectively search collections of documents for words used only in restricted senses; and design query and preference languages incorporating similarity and value filtering.
    - Investigated statistical co-occurrence techniques for texture classification of images.
  - Intelligent Collaboration and Visualization.
    - Developed initial library of collaboration middleware for data sharing, coupling and coordination.
    - Demonstrated real-time capability to discover at least 60% of relevant collaborators using graph-matching algorithms.
    - Demonstrated initial capability for teams to control shared, time-varying visualization models.
    - Demonstrated initial capability for semantic access to timed event streams and multimedia archives.

(U) **<u>FY 1999 Plans:</u>**

- Global Mobile Information Systems. ($ 18.354 Million)
  - Demonstrate application support for distributed computing in mobile environments and continuous multi-tier networking across wireless domains.
  - Prototype implementation of integrated high data-rate untethered node.

- Networking. ($ 15.172 Million)
  - Extend operation of Active Network testbed to traverse ~10 sites of ~10 switches; each using SmartPackets and composite protocols.
  - Demonstrate active node execution environment supporting resource security, and survivability functions.

- Scalable Systems and Software. ($ 37.158 Million)
  - Scalable Software.
    - Release scalable versions of defense-critical engineering software.

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- Data Intensive Computing Systems.
  - ♦ Demonstrate multiprocessor reduced instruction set computer (RISC) chip (16 issue, 1.6 gigaoperations (GOP), 5-cycle message latency).
  - ♦ Investigate instruction set extensions and storage components to allow defense applications to specify whether operations are executed in the central processor or in logic circuits embedded in the memory hierarchy.
- Ultrascale Computing.
  - ♦ Conduct system-level design and simulation study of a computation model-based on large amorphous arrays.
  - ♦ Establish role of Nuclear Magnetic Resonance (NMR) technologies in development of ultrascale computing.

• Adaptive Computing Architectures. ($ 25.169 Million)
- Debug and validate novel, configurable component technologies and architectures; demonstrate use of adaptive building blocks in wireless radio applications.
- Demonstrate 100x user-level software performance improvement over commodity microprocessors on challenge problems; release new algorithm design software environment optimized to leverage adaptive technology.

• Systems Environments. ($ 14.740 Million)
- Performance-Driven Compiler and Library Technologies.
  - ♦ Demonstrate experimental scalable structural dynamics application using DARPA sparse matrix library.
- Load Adaptive Run-time Environments.
  - ♦ Demonstrate microfeedback technologies for adaptive services.
  - ♦ Release prototype subsystem supporting adaptive resource allocation and consumption in response to changing workload and resource availability.

• Signal Processing. ($ 21.467 Million)
- Electronic Signal Processing.
  - ♦ Publish benchmarks for embedded signal processing.

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- ♦ Demonstrate enabling technologies including: Discrete Fourier Transform (DFT) chips based on clockless logic, Single Instruction Multiple Datastream (SIMD) and multi-Digital Signal Processing (DSP) board designs, Myricom 2.5 Gbps high speed configurable interconnect.
- ♦ Develop compiler and code generators to permit retargeting of commercial signal processing tools to suit tactical signal processing environments.

– Bio-Digital Signal Processing.
- ♦ Evaluate alternative mechanisms for embedded logic & communications subsystems that incorporate biological materials.
- ♦ Investigate techniques, which transduce electrical/optical/magnetic signals to/from chemical and/or biological processes.

• Defense Technology Integration. ($ 31.050 Million)

– Information Management.
- ♦ Develop framework for federation of text, image and relational databases.
- ♦ Demonstrate presentation aids for military type documents in English, Korean and a European language.
- ♦ Validate design of secure repository architecture for digital objects up to 100 megabytes in size.

– Intelligent Collaboration.
- ♦ Integrate application-specific and generic collaboration middleware.
- ♦ Develop Session Management middleware, leveraging multicasting technology that adjusts to variations in bandwidth and connectivity.
- ♦ Develop tools that enable teams and individuals to retrieve situation and task relevant information from static and dynamic archives containing a record of experiences from multi-sensory sources; and adjust team dynamics in real-time in response to changes in mission and situation.

(U) **FY 2000 Plans:**

• Global Mobile Information Systems. ($ 18.600 Million)
- – Beta-level prototype of high data-rate untethered node incorporating miniature codec.
- – Prototype implementation of mobile wireless Asynchronous Transfer Mode (ATM) networks.
- – Integrate GloMo simulation models and conduct scenario simulations for 100+ node network.

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- Networking. ($ 23.815 Million)
  - Demonstrate use of active network approach to achieve live protocol updates within two roundtrip times.
  - Release of prototype active network toolkits for end-user stations and network elements including performance measurement capabilities.
  - Engineering analysis of active network performance.
  - Initiate transfer of global scale networking technologies into distributed operational testbeds.
  - Prototype demonstration based on use of X-Bone technology to operate multiple virtual internetworks with appropriate compartmentalization of user communities.

- Data Intensive Systems and Software. ($ 28.665 Million)
  - Design processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Implement compiler that generates code compatible with processor in memory architecture.
  - Simulate data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
  - Develop architectural framework for use of data intensive technologies in embedded applications; investigate alternative approaches to package level integration of data intensive technologies with high bandwidth sensor interfaces.

- Adaptive Computing Architectures. ($ 29.739 Million)
  - Prototype implementation and runtime libraries supporting adaptive performance monitoring and analysis.
  - Demonstrate automated, model-based synthesis of heterogenous Digital Signal Processing (DSP), Application Specific Integrated Circuit/Field Programmable Gate Array (ASIC/FPGA), General Purpose (GP) system designs for large-scale systems.
  - Investigate novel approaches to in-situ logic placement and routing based on techniques such as amphorous computing.

- Systems Environments. ($ 16.200 Million)
  - Release reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Release prototype operating system with partitioned resource management for strict QoS guarantees.

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- Specify common services for scalable active software; develop technologies for just-in-time compilation and dynamic loading to support nomadic coding and the migration of continuously operating processes.
- Develop latency management framework that incorporates techniques such as optimistic processing, caching and approximation to decrease the apparent access time to remotely hosted datasets.

• Signal Processing. ($ 20.881 Million)
- Electronic Signal Processing.
  - ♦ Implement prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrate use of high performance signal processing for weapon systems applications.
  - ♦ Establish challenge problem testbed for experimental development of 1 cubic foot Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system.
  - ♦ Adapt infrared radar /ATR algorithms for use with adaptive computing systems (ACS) technology and processing of second generation forward looking infrared radar image data; enable 10Hz frame rate and perform joint demonstration with Night Vision Electronics Sensors Directorate.
- Bio-Digital Signal Processing.
  - ♦ Develop minimally invasive imaging tools for monitoring the state of ongoing biological experiments.

• Defense Technology Integration. ($ 25.000 Million)
- Joint demonstration of Quality of Service (QoS) management software with AdCon-21; employ Command, Control, Computations, Communications Intelligence Surveillance Reconnaissance (C4ISR) sensor data for targeting with total reallocation latency of less than 5 seconds.
- Alpha level prototype demonstrating integration of information management tools with high capacity storage subsystems to mask impact of limited and/or sporadic network connectivity.
- Joint field experiment (with CECOM) to characterize preference of protocols developed for use in Global Mobile Information Systems; demonstrate Multiple Beyond Line-of-Sight Communications (MUBLCOM) including voice and data.
- Develop application framework for global asset instrumentation.

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(U) **FY 2001 Plans:**

- Global Mobile Information Systems. ($ 19.000 Million)
  - Demonstrate secure multicast services over multihop, multimode network.
  - Field demonstration of proxy-enabled distributed computing in mobile environments.
  - Investigate alternative approaches capable of achieving gigabit per speed connectivity in battlefield environments.
- Networking. ($ 23.662 Million)
  - Investigate alternative approaches to large-scale network engineering including in-situ simulation technology.
  - Demonstrate performance improvements of 100% for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  - Demonstrate use of active network technology to enhance mobile/nomadic network-based services and protocols.
  - Continue transfer of global scale technologies into distributed operational testbeds.
- Data Intensive Systems and Software. ($ 28.380 Million)
  - Prototype fabrication of processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
  - Prototype demonstration of amorphous computing array.
- Adaptive Computing Architectures. ($ 31.300 Million)
  - Reconfigurable Architectures.
    - Release beta version of Adaptive Computing Systems (ACS) software including compilers and support for commercial design environments such as MatLab and Khoros; demonstrate 10x improvement in compilation times.
    - Demonstrate self test diagnosis and reconfiguration to circumvent defective and/or damaged portions of commodity logic components.

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- Reconfigurable Kernels.
  - ♦ Investigate alternative approaches to the interfaces and structure of reconfigurable kernels suitable for use in adaptive computing environments.

• Systems Environments. ($ 19.500 Million)
- Release prototype distributed object software with real-time Quality of Service (QoS) management.
- Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
- Demonstrate QoS-driven fault detection and recovery within 500 msec.
- Demonstrate on-the-fly generation of nomadic code enabling synchronization and rendezvous of multiple mobile components.

• Signal Processing. ($ 21.080 Million)
- Electronic Signal Processing.
  - ♦ Specify standard Application Program Integration (API) for data shaping and data mapping of embedded defense applications; develop prototype of visual program compiler and code generator.
  - ♦ Implement prototype system demonstrating integration of deeply networked sensors and tactical signal processing technologies.
  - ♦ Conduct bench experiments to demonstrate in situ processing of model-based automatic target recognition (ATR) data at 100,000 ray-patch intersections per second.
  - ♦ Alpha level prototype of forward-looking sonar towed array with ranging functionality and ability to form 30K independent beams.
  - ♦ Demonstration of flight-capable Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system recognizing 30 target types in presence of camouflage concealment deception.
- Bio-Digital Signal Processing.
  - ♦ Demonstrate use of high resolution imaging technology and signal transduction to effect interactive control over simple biological systems.

• Defense Technology Integration. ($ 19.000 Million)
- Field demonstration of information management tool tailored for use in environments with limited and/or sporadic network connectivity.

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- Integrate active network capabilities into Run-Time Infrastructure (RTI) for use with high-level architecture (HLA)-compliant simulations; prepare for joint demonstration with DMSO.
- Prototype demonstration of global asset instrumentation.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16.609	16.941	17.227	18.100	18.700	19.300	19.300	19.300	Continuing	Continuing

(U) **Mission Description:**

(U) Software is key to meeting DoD's increasing demand for high quality, affordable, and timely national defense systems. There is a critical need to rapidly transition state-of-the-art technology and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems. This project will fund the technology transition activities of the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense for Acquisition and Technology. It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices, and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology to practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. The SEI focuses on software technology areas judged to be of the highest payoff in meeting defense needs. FY 1997 and FY 1998 focus areas were: Technical Engineering Practices (including Information Survivability practices, Architecture-centered Software Engineering, and Commercial Off-The-Shelf (COTS)-Based Software Engineering), Enhanced Software Management Capabilities (including Software Process Improvement and Capability Maturity Model Integration (CMMI)), and Accelerating Adoption of High Payoff Software Technologies.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Technical Engineering Practices: Defined and documented administrative process and procedures for global incident response coordination. Processed guides for global incident response coordination to be used by collaborating incident response teams. A vulnerability knowledge base used by response teams was enhanced to support the collection, analysis, and sharing of security incident data. Architectural patterns supporting the integration of Commercial Off-The-Shelf (COTS) components have been identified. Attribute-specific survivability patterns for COTS-based architectures and legacy systems were demonstrated. ($ 9.400 Million)

- Enhanced Software Management Capabilities: Integrated and enhanced models for software processes, process improvement methods, and analytical capabilities to provide a common base for process assessments and improvement analysis. Released software and systems model under the CMMI framework for stakeholder review. Initiated operation of a repository for DoD software measurement data and risk management experience; released software measurement handbook and risk evaluation guidebook. ($ 5.400 Million)

- Adoption of Software Technologies: Developed guidebook for introducing technology change into organizations. Demonstrated potential utility of collaborative process technology for enhancing cooperation in responding to information warfare attacks. Provided support to establish performance measures for cost and benefits of improved practices. ($ 1.809 Million)

(U) **FY 1999 Plans:**

- Software Engineering Technical Practices: Establish/refine guidelines for helping the DoD and DoD contractors migrate legacy systems into product lines. Architecture evaluation guidelines and tradeoff techniques will be demonstrated, and an initial version of a security improvement tool kit will be developed to help system administrators protect their systems against current and emerging threats. Architecture evaluation techniques for COTS-based systems will be offered to reduce costs and risk. Training in the development of COTS-based systems will be made available for executives and program managers. ($ 11.360 Million)

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- Software Engineering Management Practices: Release of the integrated models (software, systems, and Integrated Product and Process Development (IPPD)) under the CMMI framework for public review and pilot test. Publication of Version 1 of CMMI support products. CMMI will be harmonized with International standards. Initial release of Team Software Process training. ($ 4.086 Million)

- Adoption of Software Technologies: Upgraded and expanded measurement information repository will be released to define the benefits and costs of technical practices; Development of measurement guidance for tracking performance at organizational and enterprise levels and development of guidance for the application of the Earned Value Management System (EVMS) to the development of software-intensive systems. Provide transition planning and measurement support to SEI maturation and transition activities. ($ 1.495 Million)

(U) **<u>FY 2000 Plans:</u>**

- Software Engineering Technical Practices: Define and pilot a method for survivable network technology analysis. Development of security self-evaluation method and training. Version 1 of product line acquisition guidelines and courses will be made available for use by DoD. Courses for training software engineers in the development of COTS-based systems will be available. DoD-based data on the benefits and costs of architecture analysis methods will be available. ($ 11.340 Million)

- Software Engineering Management Practices: Update and release of CMMI training, assessment and other products based on Government and industry use and feedback. Data available showing the benefits, costs, and appropriate conditions for use of Team Software Process. ($ 4.687 Million)

- Adoption of Software Technologies: Develop guidebook for introducing technology change into organizations. Additional guidance for use of metrics in software acquisition and development. Continue to provide software measurement support to all initiative work to ensure performance measures are established. Provide transition planning and measurement support to SEI maturation and transition activities. ($ 1.200 Million)

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(U) **FY 2001 Plans:**

- Software Engineering Technical Practices: Establish techniques for modeling and predicting survivability attributes of systems while they are under development. Exemplar architectures for survivable systems will be in use by DoD and industry. Standard COTS evaluation practices will be defined and in use to support the development of COTS-based systems. ($ 11.700 Million)
- Software Engineering Management Practices: Support rollout and widespread use of integrated CMM models; extend models to additional disciplines; document benefits and costs of using the integrated models; prepare for revision of models based on actual experience in their use. ($ 5.100 Million)
- Adoption of Software Technologies: Standard practices for adopting technology are in widespread use. Provide transition planning and measurement support to SEI maturation and transition activities. ($ 1.300 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Survivability ST-24	40.092	57.865	61.829	71.460	96.350	99.073	98.930	98.771	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing the technology required to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited in High Performance and Global Scale Systems (Project ST-19), Command and Control Information Systems (Project CCC-01), Information Integration Systems (Project CCC-02), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Survivability focuses on early prototypes of software technologies leading to protection for large-scale, heterogeneous systems usable over a wide range of performance in diverse threat environments. High confidence network-based systems will include security mechanisms and value-added security services for integration into network-based infrastructure as well as inherent protection mechanisms to allow the system to resist, repel and survive attack. High confidence computing systems will be developed that provide modular security services and mechanisms, provide high reliability for distributed computations, and allow geographically separated parts of an organization to interact as if they shared a common security perimeter. This also includes integrity mechanisms to allow damage to be detected rapidly. Assurance and dynamic integration tools will allow security and survivability to be inserted into legacy systems, and will enable critical systems to reconfigure and survive in the face of detected threat and successful attack.

(U) Survivability technologies will be developed to mitigate national and defense computing infrastructure vulnerabilities that could be exploited by an information warfare enemy. Intrusion detection systems will allow attacks on the defense infrastructure to be detected, the damage to be assessed, and appropriate response to be taken. Technologies will be developed to detect national security threats through correlation and analysis of observed/reported activities.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- High Confidence Networking. ($ 8.458 Million)
  - Demonstrated secure multicast protocol.
  - Demonstrated secure routing protocols with public key certificate infrastructure.
- High-Confidence Computing. ($ 9.314 Million)
  - Completed middleware for end-to-end fault tolerant realtime services on Local Area Networks (LAN).
  - Demonstrated integrated security support in prototype extensible operating system.
- Assurance and Integration. ($ 7.856 Million)
  - Implemented an initial set of wrapper components supporting security and fault tolerance.
  - Completed prototype implementation of tools for refinement of secure software architectures.
- Survivability of Large Scale Systems. ($ 14.464 Million)
  - Demonstrated techniques for detecting previously unknown attacks.
  - Developed specification for a primitive survivable "immune system" for coordinating response to attacks and intrusions.

(U) **FY 1999 Plans:**

- High Confidence Networking. ($ 16.765 Million)
  - Demonstrate secure middleware supporting distributed applications over mobile and wireless networks.
  - Demonstrate secure, multi-policy, high speed group communication.
  - Execute congressionally mandated program in software security research. ($ 0.500 Million)
  - Execute congressionally mandated program in computer security. ($ 1.000 Million)

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- High-Confidence Computing. ($ 14.838 Million)
  - Demonstrate techniques for general pairwise tradeoffs among realtime operations.
  - Evaluate prototype compiler for certifying proof-carrying code.
  - Release operating system prototype supporting efficient, secure nested virtual machines.

- Assurance and Integration. ($ 9.773 Million)
  - Complete initial wrapper-generator toolkits.
  - Demonstrate integration of security composition techniques into software engineering tools.

- Survivability of Large Scale Systems. ($ 16.489 Million)
  - Develop techniques for diagnosing multi-agent, multi-staged attack, through common Intrusion Detection Framework.
  - Demonstrate Adaptive Architecture for Survivable Systems.
  - Conduct red team exercise(s) to assess intrusion detector systems.

(U) **FY 2000 Plans:**

- High Confidence Network-Based Resources. ($ 18.400 Million)
  - Advanced prototype demonstration of secure agent network nodes.
  - Prototype demonstration of "push-back" techniques for denial-of-service attacks.

- High Confidence Data and Computing. ($ 15.700 Million)
  - Investigate basic integrity mark technology.
  - Develop tools for inserting integrity checks into mobile code.
  - Identify mechanisms that rapidly distinguish intact and corrupted data through automated verification of code and data integrity.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Assurance and Dynamic Integration. ($ 10.200 Million)
  - Complete enhanced wrapper-generator toolkits.
  - Implement prototype of artificial diversity toolkit.
  - Investigate new approaches to large-scale software composition based on software tolerances and redundancy instead of absolute correctness; identify relevant challenge problems.

- Large Scale Intrusion Assessment and Response. ($ 17.529 Million)
  - Initial design for hierarchical reporting structure for intrusion detection systems.
  - Develop experimental methods for filtering events of purely local significance.
  - Common framework for linking intrusion assessment and response components.
  - Develop workflow model supporting dynamic response capability.

(U) **FY 2001 Plans:**

- Survivability of Network-Based Resources. ($ 20.500 Million)
  - Develop techniques to isolate corrupted or malicious network entities.
  - Design active techniques for traceback and automated response.

- High Confidence Data and Program Integrity. ($ 17.360 Million)
  - Prototype demonstration of integrity mark technology supporting near continuous operation during post-attack audit.
  - Implement alpha prototype toolkit for incorporating integrity techniques into defense software.

- Dynamic Integration of Decentralized Systems. ($ 13.000 Million)
  - Prototype implementation of dynamic integration technology based on software tolerance concept.
  - Investigate market-based resource allocation mechanisms.
  - Develop methods to capture state information, for use with interrupted or suspended computation leading to experimental evaluation of software tolerance concept; down-select to most promising options for further development and challenge problem demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Large Scale Intrusion Assessment and Response. ($ 20.600 Million)
  - Design protocols to allow detectors and sensors to exchange information on their capabilities.
  - Implement initial peer-to-peer protocols allowing detection components to suppress events of purely local significance.
  - Prototype demonstration of integrated assessment and response capability.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, R-1 #13					
COST *(In Millions)*	FY 1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	0.000	70.000	70.000	70.000	70.000	70.000	70.000	Continuing	Continuing
Deeply Networking Systems AE-01	0.000	0.000	25.000	24.200	12.500	12.000	12.000	12.000	Continuing	Continuing
Software for Autonomous Systems AE-02	0.000	0.000	27.000	26.300	45.500	48.000	48.000	48.000	Continuing	Continuing
Software for Embedded Systems AE-03	0.000	0.000	18.000	19.500	12.000	10.000	10.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program is part of a multi-agency initiative to greatly extend the reach and effectiveness of networked computation. It will fund network and software research to facilitate the "deep networking" of computers, such as those embedded within DoD platforms and weapons. It will also conduct research to greatly increase the autonomy of those systems, so as to promote the human role from that of operator to supervisor.

(U) Internet technology targets only 2% of all computers, i.e., the personal computers, servers and supercomputers that are directly responsive to human operators. The remaining 98% of computers are stranded within devices whose sensors and actuators are in direct contact with the physical world. Significant productivity gains will be achieved by extending the "depth" of the network to reach these embedded devices and closing the gap between the disembodied world of command and control systems, and the physical world, which we strive to monitor and control. Similarly today's interactive software requires the constant attention of human users, who both supply the inputs and consume the results. This program will develop new approaches to software that will allow individual users to leverage hundreds, and eventually thousands, of networked processors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E

(U) The Deeply Networked Systems project will extend DoD's abilities to monitor and shape the physical environment. Doing so will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, the network infrastructure must be extended to deal with: a wide diversity of embedded devices dealing in physical world information; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients.

(U) The Software for Autonomous Systems project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) The Software for Embedded Systems project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro sensors that enable a new wave of DoD applications. For example, "smart dust" can be sowed quickly in large quantities in the battlefield to perform new monitoring functions; "smart skin" can be manufactured to conform to mission critical DoD platforms to detect, analyze and generate countermeasure waveform to enemy's radars or sonars; and a host of "Guardian Angel" sensors can be attached to warfighters to autonomously monitor safety and health information.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E

(U) **Program Change Summary:** (*In Millions*)	**FY1998**	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	0	0	0	0
Current Budget	0.000	0.000	70.000	70.000

(U) **Change Summary Explanation:**

FY 2000/01 Increase reflects establishment of a new multi-agency initiative beginning in FY 2000.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01					
COST (In Millions)	FY 1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Deeply Networked Systems AE-01	0.000	0.000	25.000	24.200	12.500	12.000	12.000	12.000	Continuing	Continuing

(U) **Mission Description:**

(U) Extending DoD's abilities to monitor and shape the physical environment will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, the network infrastructure must be extended to deal with: a wide diversity of embedded devices dealing in physical world information; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients.

(U) The large scale networking of embedded and autonomous devices creates new requirements for: multi-mode network interface technologies that can achieve drastic reductions in costs while being compatible with a wide range of network media; and flexible mechanisms for naming, addressing, configuration and administration that will make the deployment and operation of a hundred billion part infrastructure feasible. These challenges are addressed in the Network Interface component of this project.

(U) Future defense uses of the network will have an increased emphasis on the direct exchange of real-time sensor-derived information among autonomous embedded devices. This reflects a significant change in network traffic from the present environment, which is dominated by the exchange of symbolic information among human users. The new traffic models, architectures and protocols needed to effect this transition will be investigated in the Near Real-Time Networking component of this project.

(U) Many applications of deeply networked systems will perform data dissemination and fusion operations that could most efficiently be performed at nodes within the network. The Agile Network Services component of this project will leverage the capabilities of a programmable network substrate to deploy middleware that is nomadic in nature and can go where network connectivity permits. This capability will permit network elements to host services on behalf of embedded and autonomous devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Not Applicable.

(U) **FY 1999 Plans:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Multi-Mode Network Interfaces. ($ 9.000 Million)
  - Develop laboratory prototypes of efficient multi-mode interface to networks employing diverse link protocols, symbol rates, channel codings, and signaling technologies.
  - Investigate protocols for dynamic configuration of client interfaces.
  - Specify heterogeneous network architecture that integrates wireless, wireline and satellite communication; investigate addressing schemes and routing protocols to support vertical hand-offs across network boundaries.

- Near Real-Time Networking. ($ 11.000 Million)
  - Experiment with time stamping of network payloads in support of performance monitoring.
  - Conduct analysis of network and client nodes to identify key contributors to network latency.
  - Develop new traffic models to analyze impact of sensor generated information on network performance; investigate protocol interactions and cross-talk.

- Agile Network Services. ($ 5.000 Million)
  - Develop framework for automated migration of client specified proxy services to internal network nodes.
  - Investigate techniques for load balancing and service placement optimization.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01

(U) **FY 2001 Plans:**

- Multi-Mode Network Interfaces. ($ 7.000 Million)
  - Prototype implementation of network software and application interfaces for multi-mode interfaces.
  - Demonstrate high quality-of-service connectivity among wireless, wireline and satellite networks.
  - Prototype implementation of network architecture for transparent vertical handoffs between different access interface.
- Near Real-Time Networking. ($ 12.000 Million)
  - Specify architectural requirements to achieve order of magnitude reduction in worst case latency induced by packet buffering.
  - Prototype demonstration of sensor/actuator feedback loop operating over near real-time Internet.
- Agile Network Services ($ 5.200 Million)
  - Demonstrate dynamic programmability of selected network components.
  - Develop capability to support the migration of continuously operating client proxy services.
  - Demonstration of agile network services in support of distributed robotics applications.
  - Prototype implementation of middleware services that bridge the gap between logical and physical infrastructure, e.g., by providing and utilizing geo-location information.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02				
COST *(In Millions)*	FY 1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Software for Autonomous Systems AE-02	0.000	0.000	27.000	26.300	45.500	48.000	48.000	48.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) Autonomous Systems will enable revolutionary, asymmetric military capabilities, such as the ability to autonomously convey military payloads (both lethal and non-lethal) to any portion of the battlefield without requiring human operators and the ability to autonomously retrieve, process and deliver information.

(U) The Common Software for Robotics component of this project will develop a software platform that can be reused across a range of experimental autonomous systems.

(U) The Software Enabled Control component will leverage increased processor and memory capacity to vastly increase our ability to maintain control over mobile devices through the development of novel techniques, such as: predictive mode changes, dynamic control scheduling, composable control and dynamic sensor and actuator allocation.

(U) The Negotiation component will enable the autonomous operation of large collections of agents negotiating resource allocation issues, such as those encountered in logistics and countermeasures.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Not Applicable

(U) **FY 1999 Plans:**

- Not Applicable

(U) **FY 2000 Plans:**

- Common Software for Robotics. ($ 13.000 Million)
  - Develop architecture for integration of deliberative, reactive and learning behavior.
  - Define strategy to account for and integrate emergent behaviors.
  - Identify alternative approaches to software for distributed robotics.

- Software Enabled Control. ($ 9.000 Million)
  - Specify architecture for a hybrid control system that synthesizes the control law approach with computationally-enabled mode logic scalable to very large state spaces of 100K+ states.
  - Develop active transition control and joint mode logic/control law designs.
  - Implement tools for active model creation, augmentation, and query.

- Agent Based Negotiation. ($ 5.000 Million)
  - Develop framework for bottom-up organization of autonomous software.
  - Analyze autonomous software ability to predict, negotiate and track resource requirements under changing environment.
  - Implement software toolkit for knowbot development, generation and deployment.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

- Define strategy for tasking and consolidation of responses from large numbers (thousands) of software agents with minimal human intervention.

(U) **FY 2001 Plans:**

- Common Software for Robotics. ($ 12.000 Million)
  - Prototype implementation demonstrating integration of deliberative, reactive and learning behavior.
  - Laboratory demonstration of compatible knowledge representations for reprogrammable behavior-based control.
  - Prototype demonstration and experimental evaluation of software for distributed robotics capable of coordinating operation of 10+ vehicles.

- Software Enabled Control. ($ 9.800 Million)
  - Alpha-level prototype implementation of multi-mode control architecture and framework.
  - Develop parametric predictive and adaptive control frameworks.
  - Complete multi-level, multi-modal advanced design tools.

- Agent Based Negotiation. ($ 4.500 Million)
  - Prototype demonstration of autonomous software ability to utilize negotiation in logistics scenario.
  - Demonstrate and evaluate software agent's ability to approximate behavior tradeoffs and to utilize negotiation in advanced logistics scenario with a 3-second response requirement.
  - Prototype implementation of negotiation technology in real-time scenario with a 500 millisecond response requirement.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03					
COST *(In Millions)*	FY 1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Software for Embedded Systems AE-03	0.000	0.000	18.000	19.500	12.000	10.000	10.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro sensors that enable a new wave of DoD applications. For example, "smart dust" can be sowed quickly in large quantities in the battlefield to perform new monitoring functions; "smart skin" can be manufactured to conform to mission critical DoD platforms to detect, analyze and generate countermeasure waveform to enemy's radars or sonars; and a host of "Guardian Angel" sensors can be attached to warfighters to autonomously monitor safety and health information.

(U) Embedded processors interact more directly with the physical world than interactive systems, continuously monitoring changes in their environment through a variety of sensors and controlling their environment through actuators. The large scale networking of such devices creates new requirements for hardware and software components, including run-time systems that facilitate the timely acquisition, processing and exchange of sensor-derived and actuator-destined information.

(U) This project will build on Software and Networking R&D activities, extending and specializing them to sensor networks comprising millions of geographically distributed sensors. A major challenge is the development of software technologies that will allow human beings to retain supervisory control over deeply networked embedded systems, while relieving them of the "in-the-loop" burden associated with traditional interactive computing. The challenge domain for this project will be multi-taskable sensor networks. The sensor tasking, data collection, integration and analysis must be fully automated to enable operation within time constraints far shorter than could be achieved by human operators.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Not Applicable

(U) **FY 1999 Plans:**

- Not Applicable

(U) **FY 2000 Plans:**

- Common Operating Environment for Embedded Systems. ($ 8.000 Million)
  - Develop methods for distribution and operation of embedded software that allows the C^3I capabilities of embedded devices to be upgraded or altered on a near-real-time basis.
  - Initiate rapid prototyping activities using functional equivalent to target operating environment based on augmentation of COTS technology with capability to originate and host mobile code
  - Investigate suitability of aspect-oriented approaches to specification and generation of embedded systems software.
- Large Scale Networks of Sensors. ($ 7.000 Million)
  - Specify gradient-based approach to automated aggregation and distribution of information from large numbers of multi-taskable sensor nodes.
  - Determine mapping of gradient primitives to multicast and incast network protocols.
- Declarative Tasking and Querying of Embedded Systems. ($ 3.000 Million)
  - Investigate use of declarative interfaces for tasking and querying of networked embedded systems; develop alpha level prototype based on relational database query technology.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

(U) **FY 2001 Plans:**

- Common Operating Environment for Embedded Systems. ($ 7.500 Million)
  - Alpha level prototype of embedded systems operating environment incorporating native support for mobile code and ability to perform in-situ upgrades of all run-time modules.
  - Specify interfaces supporting common run-time services required by signal processing and generation applications.
  - Demonstrate dynamic generation and loading of signal processing applets.
- Large Scale Networks of Sensors. ($ 8.000 Million)
  - Implement experimental prototype supporting automated aggregation and distribution of sensor derived information involving at least 50 nodes and 100 sensors.
  - Demonstrate dissemination of sensor tasking, data collection, integration and analysis over multi-node sensor network spanning tens of square kilometers.
- Declarative Tasking and Querying of Embedded Systems. ($ 4.000 Million)
  - Prototype demonstration using declarative interfaces for tasking and querying of multi-taskable sensor networks.

(U) **Other Program Funding Summary Cost:**

- Not Applicable

(U) **Schedule Profile:**

- Not Applicable

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE February 1999

APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defense-wide
BA2 Applied Research

R-1 ITEM NOMENCLATURE
Biological Warfare Defense
PE 0602383E, R-1 #14

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	58.452	84.754	145.850	151.000	151.500	135.800	116.800	113.800	Continuing	Continuing
Biological Warfare Defense Program BW-01	58.452	84.754	145.850	151.000	151.500	135.800	116.800	113.800	Continuing	Continuing

(U) **Mission Description:**

(U) The Biological Warfare Defense program is budgeted in the Applied Research budget activity (BA-2) because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, and toxin stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprises a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to eliminate this mismatch. This program funds projects supporting revolutionary new approaches to biological warfare (BW) defense and does not duplicate efforts of other government organizations.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), pathogen countermeasures to stop pathogen virulence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific detectors, and consequence management tools. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include modified red blood cells to sequester and destroy pathogens, modified stem cells to detect pathogens and produce appropriate therapeutics within the body, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other significant pathogens, and identify the pathogen even in the absence of recognizable signs and symptoms (when the pathogen numbers are still low).

(U) The ability to detect biological warfare agents on the battlefield in real time with no false alarms is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized (shoe box-size) time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby saving at least 20 minutes in time to identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats, determine live vs. inactivated threat status, and report functional consequences of exposure (mechanisms of action).

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. This project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Pathogen Countermeasures. ($ 43.086 Million)
  - Optimized the detection of specific pathogens by stem cells (in cell culture).
  - Determined the impact of modified red blood cells on the vascular and immune systems.
  - Defined animal models in which to test the efficacy of modified red blood cells to defend against pathogens.
  - Developed enzymes and other active molecules which can be attached to the surface of red blood cells to detect and destroy pathogens.
  - Established a portfolio of strategies to:
    - Inhibit the expression of disease causing (virulence) factors by pathogens.
    - Disrupt the disease causing (virulence) communications between pathogens.
    - Modulate the body's response to the presence of a pathogen.
    - Assess the feasibility of novel polymeric materials to protect against pathogen exposure.
  - Assessed the feasibility of an array-based instrument (and other novel technologies) for multi-agent pathogen diagnosis in medical samples.

- Sensors. ($ 7.788 Million)
  - Developed a hierarchical database of mass signatures for use in detecting selected bacteria with a mass spectrometer.
  - Investigated methods for determining biological warfare agent bacterial and viral viability (agent live or dead).
  - Demonstrated the feasibility of using giant magnetoresistance for the detection of magnetic bead-tagged pathogens.
  - Fabricated and tested a wick device, an integral sample pump, and a reagent reservoir system suitable for use in a handheld Up-Converting Phosphor detector.
  - Developed a biochip for rapid pathogen identification.
  - Engineered cells for pathogen specificity and amplification.
  - Engineered cells with optical signals in response to pathogen detection.
  - Identified limiting performance variables for cells in tissue based detection schemes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Consequence Management. ($ 7.578 Million)
  - Demonstrated a biological warfare Anchor Desk that provides agent-specific biological warfare (BW) situational awareness, decision and execution support with linkages to the Logistics Anchor Desk (LAD) for BW-specific logistical information.
  - Developed agent-specific "software antibodies" for detection, protection, and treatment directives to medical personnel for biological warfare (BW) threats that will decrease response time.
  - Developed quantitative measures of operational assessment using Medical Readiness Indicators (metrics based indicators of individual and unit level readiness) and realistic BW training algorithms to improve the medical response to a biological warfare incident.
  - Demonstrated Enhanced Consequence Management Planning and Support System (ENCOMPASS) during BIO 911 and other exercises for command and control of biological warfare incidents.

(U) **FY 1999 Plans:**

- Anti-Virals/Immunizations. ($ 14.820 Million)
  - Develop a modified stem cell, which can both detect and produce a prophylactic/therapeutic response to a pathogen (in cell culture).
  - Determine (in-vitro) toxicity of modified stem cell-produced therapeutics.
  - Create techniques to rapidly develop immunization strategies against bacterial and viral pathogens and toxins.

- Anti-Bacterials/Anti-Toxins. ($ 14.858 Million)
  - Develop and test (in-vitro) cellular platforms for toxin destruction and toxin binding decoys.
  - Demonstrate selected strategies (in cell culture) to:
    - Inhibit the expression of disease causing (virulence) factors by pathogens.
    - Disrupt the disease causing (virulence) communications between pathogens.
    - Modulate the body's response to the presence of a pathogen.

- Multi-Purpose. ($ 12.000 Million)
  - Define animal models in which to test the efficacy of modified stem cells to prevent disease.
  - Demonstrate in laboratory animals the efficacy of modified red blood cells to eliminate pathogens from the blood for the purpose of potential defense against BW agents.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
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- Determine pathogen detection and elimination efficacy for modified red blood cells with enzymes or other active molecules attached to their surfaces.

• External Protection. ($ 7.214 Million)
- Develop polymeric materials for pathogen protection.
- Demonstrated in-vivo broad-spectrum efficacy of non-toxic biological decontamination formulation.

• Advanced Diagnostics. ($ 10.800 Million)
- Determine appropriate bodily sample types (blood, saliva, sputum, etc.) to use for diagnosis.
- Determine which non-biological warfare (BW) pathogens must be screened against because they mimic early symptoms of known BW threat agents.
- Begin identification of probes to be used in diagnosis systems.
- Evaluate the feasibility of novel technologies and sampling strategies, such as detecting bodily responses indicative of infection.

• Sensors. ($ 15.462 Million)
- Continue development of air sampling technology for airborne biological materials.
- Determine chemotaxonomic biomarkers for selected viral substances for detection in the mass spectrometer.
- Demonstrate replacement of a surface-bound antibody with a "designer" small molecule for high affinity pathogen capture.
- Develop high affinity monoclonal antibody that recognizes only anthrax spores without cross-reactivity with vegetative cells (or other bacillus species) and test in existing BW sensors for improved performance.
- Complete Up-Converting Phosphors (UCP) detection system and field test.
- Modify the prototype of a miniature biodetection system following Dugway Proving Ground test results.
- Select cell and tissue types for the development of tissue based sensors.
- Examine and select strategies to stabilize cell systems for long-term shelf life and functional response.
- Demonstrate the ability to modify the duty cycle of a cellular response in single cell and tissue based sensors.
- Demonstrate performance limits of a single cell sensor.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Consequence Management. ($ 8.600 Million)
  - Develop software toolkit for Enhanced Consequence Management Planning and Support System (ENCOMPASS).
  - Perform additional field tests of BW defense attack response planning tool and electronic watchboard.
  - Develop electronic watchboard architecture and biological warfare (BW) incident playbook authoring and maintenance tools.
  - Transition BW Medical Readiness Indicators to the Services.

- Multimedia/Telemedicine. ($ 1.000 Million)
  - Develop enhanced telemedicine capability for war fighter by augmenting/tailoring wireless communication technology appropriate for responses to biological warfare attacks.

(U) **<u>FY 2000 Plans:</u>**

- Anti-Virals/Immunizations. ($ 20.500 Million)
  - Identify broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.
  - Develop a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
  - Develop technologies for rapid design and development of new vaccines against novel pathogens.
  - Demonstrate (in-vitro) candidate anti-viral and anti-bacterial small molecule therapeutics for selected targets.
  - Demonstrate (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.

- Anti-Bacterials/Anti-Toxins. ($ 18.300 Million)
  - Develop (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Validate the efficacy (in-vivo) of antagonists to toxin receptors, toxin catalytic sites, and cellular platforms for toxin destruction.
  - Demonstrate (in-vivo) toxin-blocking antibodies and toxin binding decoys.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial antagonist.
  - Use gene-shuffling techniques to generate molecules to be screened for superantigenic properties.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Multi-Purpose. ($ 20.000 Million)
  - Explore concepts for therapeutics against bioregulators and other mid-spectrum agents.
  - Identify primary harmful immune responses to BW agents.
  - Explore concepts for optimizing human immune response to biological warfare (BW) agents, minimizing negative sequelae.
  - Demonstrate in laboratory animal models the ability of modified stem cells to prevent disease.
  - Develop synthetic polymer complements for pathogenic antigens and virulence factors.
  - Identify monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Identify polyvalent inhibitors for inhibiting pathogens on the surface of target cells in-vivo.

- External Protection. ($ 18.500 Million)
  - Develop decoy molecules that will prevent the adhesion of multiple pathogenic toxins or viruses in-vivo.
  - Demonstrate (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.
  - Demonstrate initial performance of a prototype device for the purification of water contaminated with BW agent simulants.
  - Explore high throughput methods for the purification of contaminated air.
  - Demonstrate effectiveness of specific personnel protective toxin and pathogen neutralization strategies against virulent biological agents.
  - Continue development of prototype protective system and initiate integration into personnel protective systems.

- Advanced Diagnostics. ($ 18.700 Million)
  - Continue identification and development of probes to be used in diagnosis systems, and begin testing of probe panels in the laboratory.
  - Develop sample preparation techniques to optimize speed, accuracy, and reliability of diagnosis.
  - Identify one or more promising strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure (including non-invasive early detection of disease [e.g., NO in exhaled breath]).
  - Determine range of cytokine levels in the healthy body verses an infected body using laboratory animals and cell cultures as models.
  - Determine feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determine feasibility of rapid single molecule DNA sequencing for accelerated patient diagnosis.
  - Explore concepts for diagnosing patients for bio-regulator and other mid-spectrum agent attack.

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- Sensors. ($ 33.850 Million)
  - Complete, test, and verify first-generation prototype of live agent biochip sensor.
  - Complete development of air sampling technology for airborne biological material.
  - Continue development of effective and rapid chip-reading capability with enhanced sensitivity.
  - Continue the development of unique signatures for bio-agents in mass spectrometry identification.
  - Develop biosensor technology for next-generation (bioengineered) threat agents.
  - Develop methods for identifying bioregulator-based biological warfare (BW) agents.
  - Evaluate chemical clues used by biological systems in normal hunting strategies to revector the biological systems to search for BW agent production or storage.
  - Explore options (e.g., training, genetic engineering, etc.) for the use of invertebrates in the detection of BW agents and associated chemicals.
  - Construct cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
  - Optimize electronic interfaces for optical and electrical reporting from cell and tissue based sensors.
  - Investigate optimal system designs for deployment of a single cell and tissue based biosensor, which incorporate environmental sampling, microfluidics, and automated detection.
  - Evaluate cell and tissue based informatics from temporal and spatial signals in cell and tissue-based sensors.
  - Explore shelf-stabilization strategies for cells and tissues.
  - Develop bio-agent sensors for use in building protection.
  - Develop capability to predict flow of airborne bio-agents in and around buildings.

- Genetic Sequencing of Biological Warfare Agents. ($ 4.000 Million)
  - Develop inventory of DoD-relevant BW agent pathogens requiring sequencing.
  - Determine best methods for rapidly sequencing biological warfare pathogens and related species and strains.
  - Begin development of database mining techniques to find new targets for sensors, diagnostics, and therapeutics.

- Consequence Management ($ 12.000 Million)
  - Develop distributed BW consequence management smart checklists for automatic pull and push of required information.
  - Continue development of Enhanced Consequence Management Planning and Support System (ENCOMPASS) software toolkit.

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- Continue development of playbooks and incorporate Incident Command System capabilities.
- Demonstrate use of ENCOMPASS for OCONUS air base force protection against a BW attack.
- Demonstrate use of playbooks and automated checklists for training BW incident responders.

(U) **FY 2001 Plans:**

- Anti-Virals/Immunizations. ($ 21.300 Million)
  - Validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
  - Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
  - Demonstrate the efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
  - Demonstrate (in-vivo) the rapid design and development of new vaccines (or therapeutics) against unidentified or unknown pathogens.
  - Demonstrate broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.

- Anti-Bacterials/Anti-Toxins. ($ 19.500 Million)
  - Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial pathogen antagonist.
  - Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Demonstrate (in-vivo) efficacy of broad spectrum, superantigenic, antitoxin antagonists and vaccines.

- Multi-Purpose. ($ 22.100 Million)
  - Develop therapeutic strategies against bioregulators and other mid-spectrum agents.
  - Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
  - Develop therapeutic strategies for minimizing harmful immune responses to biological warfare agents.
  - Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Validate polyvalent inhibitors for blocking pathogens on the surface of target cells in-vivo.
  - Identify superantigens for broad protection against biological warfare agents with minimal side effects.

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- Validate (in-vivo) the efficacy of subcellular pathogen response imaging for rapid detection.
- Validate technologies broadly applicable to enhance cellular therapeutics (delivery platforms) and virulence modulation (intracellular and inflammatory cascades).

• External Protection. ($ 20.600 Million)
- Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
- Demonstrate a non-aqueous advanced decontamination method.
- Demonstrate scalability of a water purification system effective against a range of biological agents (including toxins and bioregulators).
- Build and test a prototype air purification system for individual soldiers.
- Begin testing of prototype protective system against non-virulent biological warfare (BW) agents.
- Begin testing of prototype protective system against bio-toxins and bio-regulators.

• Advanced Diagnostics. ($ 21.000 Million)
- Test probe panels in relevant sample types including strategies for rapidly generating new/novel probes.
- Demonstrate that sample collection and/or preparation techniques do not introduce artifacts.
- Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
- Develop the capability to diagnose exposure to bio-regulator and mid-spectrum agents.
- Demonstrate, in the laboratory, the feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
- Evaluate the feasibility of a strategy for detection of disease using exhaled breath.
- Evaluate the feasibility of additional strategies for direct identification or detection of infection without direct sample collection.
- Demonstrate the ability to perform accelerated patient diagnosis using a rapid single molecule DNA sequencing technique in a model system.

• Sensors. ($ 34.000 Million)
- Continue the development of effective and rapid chip-reading capability with enhanced sensitivity and low false alarm rate.

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- Continue the development of advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
- Evaluate methods for removing micro-encapsulation of disguised pathogens and/or sensing through the micro-encapsulation.
- Continue the development of technologies required for next-generation miniature biological detectors including the use of microelectromechanical systems (MEMS), microfluidics, and mesoscopic-sized components.
- Evaluate false positive and false negative rates for systems of detectors.
- Exploit and/or mimic the olfactory sensors of biological systems for use in the detection of biological warfare agents.
- Engineer a deployable prototype cell and tissue sensor for field-testing.
- Demonstrate enhanced signal output from engineered cells and tissue based sensors.
- Integrate information from cell and tissue sensors with user interfaces for predictive responses.
- Develop concepts for sensors capable of detecting biological warfare agent production in underground facilities.
- Investigate critical design parameters for advanced biologically based BW sensor.
- Validate bio-agent sensors for use in building protection.
- Continue development of capability to predict flow of airborne bio-agents in and around buildings.
- Determine optimal sensor placement for building protection.

• Genetic Sequencing of Biological Warfare Agents. ($ 2.500 Million)
- Continue development of database mining techniques and test on a subset of pathogenic genomes.
- Transition sequencing activity to Department of Energy funding.

• Consequence Management. ($ 10.000 Million)
- Demonstrate rapid construction and distribution of specific BW smart checklists for multiple responders.
- Demonstrate Enhanced Consequence Management Planning and Support System (ENCOMPASS) management of multi-site BW incidents.
- Demonstrate automatic construction of incident- and responder-specific playbooks and electronic watchboards.
- Demonstrate use of ENCOMPASS for CONUS air base force protection against BW attacks.
- Transition ENCOMPASS to National Guard Rapid Assessment and Initial Detection Units and to Air Force Theater Battle Management Core.

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(U) **Program Change Summary:** *(In Millions)*

	FY1998	FY1999	FY2000	FY2001
Previous President's Budget	60.805	88.000	77.300	74.000
Current Budget	58.452	84.754	145.850	151.000

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects SBIR reprogramming and minor program repricing.

FY 1999 Decrease reflects net effect of congressional program and undistributed reductions; congressional add for BW telemedicine demonstration and below threshold reprogramming.

FY 2000/01 Increases reflect Departmental direction to expand biological warfare efforts in the following areas: biological agent detectors; enhanced medical diagnostics and therapeutics; air and water purification technologies; and genetic sequencing of biological warfare agents.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, R-1 #16

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	140.997	169.759	137.626	123.937	172.330	212.514	227.942	241.306	Continuing	Continuing
Naval Warfare Technology TT-03	17.948	23.100	10.780	7.807	21.140	20.917	20.774	20.615	Continuing	Continuing
Advanced Land Systems Technology TT-04	20.330	37.620	39.290	40.321	49.854	54.831	54.688	54.529	Continuing	Continuing
Advanced Targeting Technology TT-05	0.000	0.000	0.000	0.000	8.400	36.700	46.700	56.700	Continuing	Continuing
Advanced Tactical Technology TT-06	53.059	47.859	32.083	20.463	26.968	43.673	43.530	43.371	Continuing	Continuing
Aeronautics Technology TT-07	19.185	30.694	35.385	35.346	39.168	39.593	45.450	49.291	Continuing	Continuing
Advanced Logistics Technology TT-10	20.685	20.853	10.352	10.000	16.800	16.800	16.800	16.800	Continuing	Continuing
Joint Logistics TT-11	9.790	9.633	9.736	10.000	10.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Targeting, Aeronautics, and Logistics technologies.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E

(U) The Naval Warfare Technology project is focusing on: Command, Control, Communications and, Intelligence/Synthetic Environments (C3I/SE), Digital Terrain Mapping, High Energy Density Materials, and Submarine Payloads and Sensors. In the C3I/SE program, advanced information technologies are being integrated into advanced prototype systems to provide improved battlefield awareness and dominance to mobile command centers in the field. Digital Mapping efforts are focused on demonstrating a lightweight, broadband phased-array antenna and altitude measuring system that will produce real-time 3D maps of littoral environments. The High Energy Density Materials program is exploring high risk/high pay-off breakthroughs in missile propellants and explosives technologies. The Submarine Payloads and Sensors effort will explore submersible platforms designed to maximize payload capacity.

(U) The Advanced Land Systems Technology project is developing technologies for contingency missions, mine clearing, and anti-personnel landmine alternatives to make U.S. combat forces more deployable, effective, survivable, and affordable. The SLID program will develop and test a system for providing protection against missiles and projectiles with explosive warheads. The Advanced Fire Support Systems program will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Dog's Nose/Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Glass Turret program will address vehicle survivability and targeting functions, for future combat vehicles. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines. The Simulated Battlefield Imagery program will investigate computer-generated imagery for battlefield shaping and deception of enemy units.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; compact high-density holographic data storage and high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems. In addition, the project funds technologies which focus on precision optics components for critical DoD applications, miniature air-launched decoy systems, affordable rapid response missile demonstrations, and new tactical systems for enhanced air vehicle survivability, advanced air breathing weapons, and emerging payload delivery concepts.

(U) The Aeronautics Technology project will develop and demonstrate a new family of Micro-Aerial Vehicles (MAVs). The MAVs will be an order of magnitude smaller than any operational UAV and will be useful in a wide variety of military missions from covert imaging and chemical/biological agent detection to communication enhancement. This project also funds the Micro Adaptive Flow Control program, the Vertical Take-off and Landing Unmanned Air Vehicle program, small-scale propulsion system concepts, and the Advanced Rotorcraft Technology program.

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(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently.

(U) The Joint Logistics project is a multi-part Advanced Concept Technology Demonstration (ACTD) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the service logistics communities. Part 1 will develop JDST capabilities in the areas of force capability assessments, logistic support concepts and plan generation, distribution, materiel management; maintenance analysis and visualization. Part 2, the Joint Theater Logistics ACTD, will integrate and extend those capabilities to provide realtime in-theater management and analysis tools. Focus areas for the Joint Logistics project correspond to Commander-In-Chief (CINC) and Service requirements to develop JDSTs.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	148.331	188.995	186.619	212.597
Current Budget	140.997	169.759	137.626	123.937

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects transfer of Facial Recognition Technology Program to SOLIC; transfer of Simulation Based Design Program to DLA; SBIR reprogramming; inflation savings reduction; and minor program repricing.

FY 1999 Decrease reflects net effect of congressional program and undistributed reductions; congressional adds for CEROS and Simulation Based Design; and minor below threshold reprogramming.

FY 2000/01 Decreases reflect completion of the Miniature Air Launched Decoy program in Project TT-06; transfer of Canard Rotor/Wing (CRW) and A160 efforts from Project TT-07 to PE 0603285E; and transition of the Genoa program from Project TT-03 to PE 0603760E, Project CCC-01.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Naval Warfare Technology TT-03	17.948	23.100	10.780	7.807	21.140	20.917	20.774	20.615	Continuing	Continuing

(U) **Mission Description:**

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The enabling technologies include: Command, Control, Communications, and Intelligence/Synthetic Environments (C3I/SE) for littoral warfare; all weather interferometric sensor technology for precision 3-D terrain height estimation and surveillance of littoral environment for smart Naval Fire Support (NFS) weapons; investigations into High Energy Density Materials (HEDM) for advanced explosives and propellants; and innovative design concepts for expanding the envelope of operational capabilities for submersible platforms.

(U) In the Command, Control, Communication, and Intelligence/Synthetic Environment (C3I/SE) area, advanced information technologies are being integrated and applied to provide improved battlefield awareness and battlefield dominance to mobile command centers in the field (e.g., Force Commanders, Commander Joint Task Force (CJTF), and deployed Joint Special Operations Task Force (JSOTF) Commanders). The advanced prototype systems developed under this program integrate the latest technologies in high-bandwidth communications, object oriented information system, collaborative planning, intelligent database access, image processing, data exploitation, and high performance computing to address the unique (quick reaction and real-time execution) requirements of forward deployed, mobile commanders. The program developed systems design for collaborative crisis understanding and mitigation, developing tools and systems necessary to recognize, understand, forecast, and defuse potential crisis situations. Project Genoa will substantially reduce the time necessary to form teams, analyze crisis data, and develop and brief response options. This effort is focused on the commanders from the National Command Authority to the commanders of the unified commands.

(U) 3-D High-Resolution Digital Terrain Mapping will support the Naval Fire Support (NFS) missions in the littoral environment by development of advanced 3-D radar technologies which will enable the CJTF to obtain precise, near-real time 3-D maps of littoral environments. These precision 3-D maps provide accurate position information of all objects in the littoral theater and will be required for next generation smart munitions and surveillance systems. All weather interferometric sensors for precision 3-D terrain height estimation and surveillance of littoral environment will require the development of precision position and velocity measurement systems using inertial navigation systems tightly coupled

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with space based precision frequency and time sources. This effort will also develop and demonstrate advanced radar imaging techniques and processing algorithms required for precision geolocation by standoff sensors, particularly error reduction by multi-scene fusion.

(U) The High Energy Density Materials (HEDM) program fosters high-risk/high payoff efforts that could result in major breakthroughs in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project will investigate the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The stability and energy content of several such molecules have been predicted theoretically. The molecules will contain only nitrogen atoms or a very high percentage of nitrogen atoms, a situation that makes their production and use environmentally friendly. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of detectability. Missile systems with size constraints could have increased range, maneuverability for flexible targeting, and/or increased kill effectiveness due to improvements in both the propellant's thrust and the warhead's lethality (per weight and volume). The program builds on theoretical work previously sponsored by other DoD organizations and provide some high risk excursions into materials which are theoretically possible but for which there is no currently known defined synthetic route.

(U) Current submarine designs are significantly limited in the quantity and types of payloads and sensors that can be accommodated; in turn, these limitations increasingly constrain the view of the future operational utility of the submarine platform. Recently completed high level studies have highlighted the critical need to address these limitations if the stealth, inherently available to submerged platforms, is to remain tactically relevant into the future. The Submarine Payloads and Sensors Program is intended to explore the possibilities that emerge when a unified set of payload and sensor concepts, operational implications, and supporting platform concepts are formulated in a balanced manner. Flexible platform concepts will be developed that support multiple payload/sensor concepts across the areas of advanced ordnance, advanced sensors, and adjuvant vehicles. To enable the breadth of thought and innovation necessary to make this effort a success, it is structured as a concept development and exploration utilizing competing multi-disciplinary design teams that cut across a spectrum of industry. Technology and programmatic roadmaps for the interlocking payload, sensor, combat system and platform concepts that evolve will be defined as part of this phase.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Continued systems development and initiated development of a tool for rapid, collaborative option development, evaluation, and presentation; demonstrated and evaluated retrieval agents; demonstrated use of access templates and profiles; evaluated filters. Demonstrated the ability to navigate several of the most important, crisis-related databases for acquiring information on a simulated crisis. ($ 3.200 Million)

- Evaluated ability to quantify centers-of-gravity and pressure points for option development, and demonstrated modeling capabilities at Joint Task Force ATD/Global Command and Control System Insertions. Demonstrated crisis presentation capability for prioritizing policy and plans at National Security Council/National Military Command Center and supporting intelligence agencies. ($ 4.411 Million)

- Demonstrated production of Digital Terrain Elevation Data (DTED) near level 5 accuracy using multiscene Interferometric Synthetic Aperture Radar (IFSAR) and verified by Light Detection and Ranging (LIDAR). Successfully simulated interwoven Synthetic Aperture Radar (SAR)/Ground Moving Target Indicator (GMTI) tasking. ($ 1.500 Million)

- High Energy Density Materials (HEDM): Initiated focused synthesis; established parallel supporting efforts in theoretical chemistry, kinetics and thermodynamics at five US government and national labs as well as two universities. Also established an international agreement with the government of Sweden to investigate novel approaches to the synthesis of N_4 molecules. ($ 1.979 Million)

- The following activity was added by Congress to the FY 1998 President's Budget:
  - Center of Excellence for Research in Ocean Sciences (CEROS) - Continued most promising ocean science efforts at the CEROS. ($ 6.658 Million)

- Conducted technical study to assess feasibility of acoustic thermography; controlling and monitoring temperature using non-invasive acoustic methods. ($ 0.200 Million)

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(U) **FY 1999 Plans:**

- Demonstrate initial operational capability of the data retrieval and visualization capability, initial operational capability of the crisis modeling capability, and begin installation of modeling capability and integration with data retrieval capability at CINCPAC and DIA. Begin installation and integration of advanced presentation capability. During FY 1999, Project Genoa is beginning the advanced technology stage and is transitioning into PE 0603760E, Command Control and Information Systems, Project CCC-01. ($ 7.034 Million)
- Continue development of synthesis pathways and theoretical chemistry support activities for High Energy Density Materials (HEDM); investigate methods to scale-up successful synthetic routes to production quantities. ($ 2.451 Million)
- Commence concept development phase of Submarine Payloads and Sensors Program, defining innovative concepts in advanced ordnance, advanced sensors, and adjuvant vehicles applicable to submarine platforms. Conduct operational utility assessments of candidate payload and sensor concepts to assess their battlefield payoff and ability to enable new missions. ($ 4.615 Million)
- The following activities were added by Congress to the FY 1999 President's Budget:
  - Center of Excellence for Research in Ocean Sciences (CEROS) - Continue most promising ocean science efforts at the CEROS. ($ 7.000 Million)
  - Simulation-Based Design (SBD) – Continue simulation based design and virtual reality efforts, in a collaborative program with private industry, for the Gulf Coast Regional Maritime Technology Center. ($ 2.000 Million)

(U) **FY 2000 Plans:**

- Scale up synthesis of High Energy Density Materials (HEDM) to gram quantities and experimentally verify physical properties. ($ 4.953 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03

- Complete concept development phase of Submarine Payloads and Sensors Program. Define flexible platform concepts capable of supporting selected payload and sensor concepts. Identify development roadmaps and supporting technology risks and opportunities. ($ 2.438 Million)
- Commence risk reduction and initial prototyping of selected payload and sensor concepts emerging from the Submarine Payloads and Sensors Program. ($ 3.189 Million)
- Conduct technology assessments and feasibility testing of advanced naval warfare technologies, including hybrid electric propulsion and power management techniques. ($ 0.200 Million)

(U) **FY 2001 Plans:**

- Continue High Energy Density Materials (HEDM) development and physical property verification; assess HEDM system applications. ($ 4.975 Million)
- Continue risk reduction and initial prototyping of payload and sensor concepts developed in the Submarine Payloads and Sensors Program. ($ 2.832 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Land Systems Technology TT-04	20.330	37.620	39.290	40.321	49.854	54.831	54.688	54.529	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing technologies for contingency missions, deployments, and military Operations-Other-Than-War (OOTW) to make U.S. combat forces more deployable, effective, survivable, and affordable. This project supports seven main efforts: Small Low-Cost Interceptor Device (SLID); Advanced Fire Support Systems; Counter-artillery Force Protection (CFP); Dog's Nose/Unexploded Ordnance Detection; Alternatives to Antipersonnel Landmines; Simulated Battlefield Imagery; and Glass Turret (GT).

(U) The SLID program is developing and testing a system, which protects threatened systems against missiles and projectiles with explosive warheads. The SLID system will detect, track and intercept threats such as anti-armor missiles, mortars, artillery, and top-attack sensor fused munitions at a standoff distance sufficient to render them ineffective. Applications for the SLID system include: self-defense of vehicles; defense of high value fixed sites such as command centers, hospitals, embassies, parked aircraft and radars; and, with further development, self defense of naval platforms and low-speed aircraft.

(U) The Advanced Fire Support Systems (AFSS) program will develop and test a containerized, platform independent multi-mission weapon concept. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, and lower life-cycle costs, while increasing survivability compared to current gun and missile artillery. AFSS will allow the military to more completely capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. It will also allow the Army to streamline its missile acquisition plan around future common missiles. The program will develop and demonstrate highly flexible systems including a modular, multimission precision missile, a remotely commanded self-locating launcher, and a command and control system compatible with military doctrine.

(U) The Counter-artillery Force Protection (CFP) program will develop concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program will explore advanced sensors, munitions and deployment concepts to counter this evolving threat. System concepts will be developed and analyzed.

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(U) The Dog's Nose/Unexploded Ordnance (UXO) Detection program will develop sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program will provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors will work either singly or in conjunction with other technologies such as the hyperspectral mine detector, developed under the Small Unit Operations (SUO) program that exploit different physical features.

(U) DARPA is developing technologies that provide alternatives to antipersonnel landmines (APLs) under this project. The systems developed will provide our warfighter with enhanced capabilities that obviate the need for APL. Technologies include self-healing antitank (AT) minefields (that allow the protection of AT mines without the use of APL) and tags with minimally guided munitions that allow the compression of critical timelines and distances constraints imposed by conventional indirect and direct fire approaches.

(U) The Simulated Battlefield Imagery program is investigating opportunities for the computer generation and projection of high fidelity battlefield imagery to be employed as an area denial technique through battlefield shaping and deception of the enemy at the unit level. In order to achieve effective real-time battlefield shaping, the program is focusing on the development of the capability to produce rapid computer generated characters. This effort builds on current DARPA programs focusing on Advanced Simulation of synthetic battlespaces for training and mission rehearsal activities.

(U) The Glass Turret (GT) program will develop an integrated sensor system, which performs both vehicle survivability and targeting functions for future combat vehicles. The program will take radar and electro-optic technologies developed under the: Small Low-Cost Interceptor Device (SLID) program and extend its capabilities to include other required functions, such as reconnaissance, surveillance and targeting. The program will also address display systems and human factors. Particular attention will be placed on minimization of signatures from both active and passive sensors.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Small Low-Cost Interceptor Device (SLID). ($ 6.601 Million)
  - Completed development leading to live-on-live Small Low-Cost Interceptor Device (SLID) testing.
- Unexploded Ordnance Detection. ($ 10.729 Million)
  - Demonstrated laboratory scale system for chemically specific detection of land mines.
- Advanced Fire Support System (AFSS). ($ 3.000 Million)
  - Conducted concept and requirements analysis for platform independent and unmanned missile artillery packages.
  - Developed baseline concept designs.

(U) **FY 1999 Plans:**

- Small Low-Cost Interceptor Device (SLID). ($ 9.000 Million)
  - Complete vehicle self-protection testing.
  - Transition ground vehicle active protection technology to Army.
  - Develop active survivability capabilities against unitary munitions for both vehicle and ground forces, including extension of SLID protection range for application to high value fixed sites. Investigate integration with passive countermeasures.
- Unexploded Ordnance Detection. ($ 14.713 Million)
  - Field demonstration of prototype chemically specific land mine detector paired with other sensors as appropriate.

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- Advanced Fire Support System (AFSS). ($ 6.907 Million)
  - Continue feasibility analysis of advanced technologies for integration into platform/missile system components.
  - Develop detailed designs for the Advanced Fire Support System architecture.
  - Conduct evaluations and testing of high risk and critical components.
  - Define system demonstration objectives.

- Alternatives to Antipersonnel Landmines. ($ 7.000 Million)
  - Investigate system design issues for self-healing antitank minefields including distributed communications and propulsion mechanisms.
  - Analyze parameters, including power, communication, and attachment mechanisms, to permit tagging of individuals for tags and minimally guided munitions concept.
  - Investigate the effects of alternatives to antipersonnel land mines on the behavior of individual soldiers and units.

(U) **<u>FY 2000 Plans:</u>**

- Advanced Fire Support System (AFSS). ($ 18.190 Million)
  - Complete detail design for AFSS objective demonstration system, including launch, fire control, and each of the demonstration flight systems.
  - Develop and test component hardware and software for AFSS.
  - Continue advanced concept feasibility assessments.
  - Initiate hardware-in-the-loop tests.
  - Plan and initiate limited objective flight tests.

- Counter-artillery Force Protection (CFP). ($ 1.100 Million)
  - In conjunction with the Army, define one or more system architectures, including sensors, munitions and deployment to meet the mission needs for enclave protection against missile artillery.

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- Alternatives to Antipersonnel Landmines. ($ 13.000 Million)
  - Completion of antitank minefield healing algorithms.
  - Initial demonstration of self-healing antitank mines – individual mine-surrogates movement and communication among several mine-surrogates.
  - Development and demonstration of tagging concept(s) in the laboratory.

- Simulated Battlefield Imagery. ($ 7.000 Million)
  - Initial study analyzing fidelity and extent of battlefield images required to deceive and shape response of individual soldiers.
  - Identify opportunities to achieve enhanced rapid computer generation of militarily relevant images.
  - Demonstration of simple insertion of computer generated characters in typical field background under a discrete number of lighting and environmental conditions.

(U) **FY 2001 Plans:**

- Advanced Fire Support System (AFSS). ($ 12.000 Million)
  - Complete system hardware and software development.
  - Complete limited objective flight tests.
  - Plan and initiate preparations for full system demonstrations.

- Alternatives to Antipersonnel Landmines. ($ 8.000 Million)
  - Field demonstration of self-healing antitank minefield using surrogate mines.
  - Demonstrate adhesion of tags in the field.
  - Demonstration of in-field wakeup and down-range communication with tags.

- Organic Real-time Battlefield Shaping. ($ 14.000 Million)
  - Demonstrate simulated battlefield images for realistic battlefield shaping.
  - Analyze system requirements for in-field projection techniques of simulated battlefield images.
  - Initial demonstration of potential projection techniques in the laboratory.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04

- Glass Turret (GT). ($ 4.000 Million)
  - Begin development of integrated radar and electro-optic suite.
  - Begin development of integrated display system.
- Perform feasibility studies and analysis to assess military utility of the precision guided munitions concept. ($ 2.321 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Tactical Technology TT-06	53.059	47.859	32.083	20.463	26.968	43.673	43.530	43.371	Continuing	Continuing

(U) **Mission Description:**

(U) This project focuses on six broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, sensors, and high-power applications; (b) compact high density holographic data storage for high bandwidth image processing and access to large data bases; (c) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (d) precision optics components for critical DoD applications; (e) miniature air-launched decoy systems; and (f) an affordable rapid response missile demonstration. Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, and emerging payload delivery concepts.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Compact Lasers. ($ 2.271 Million)
  - Demonstrated compact high power tunable lasers and laser diodes at mid-infrared wavelengths.
  - Developed breadboard tunable mid-infrared lasers for closed-loop infrared countermeasures.
- Holographic Data Storage. ($ 2.128 Million)
  - Demonstrated 1 terabit storage capacity for functional evaluation of holographic data storage systems.
- High Performance Algorithm Development. ($ 11.819 Million)
  - Implemented a hybrid automatic target recognition strategy for synthetic aperture radar exploiting most advantageous features of wavelets and nonlinear partial differential equation-based methods.
  - Developed application-specific wavelet-based automatic target recognition algorithms.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

- Continued development of most promising strategies for data, sensor, and algorithm fusion that exploit the feature extraction capability of wavelets with applications to signal and image processing.
- Developed prototype electromagnetic scattering models for objects in ground clutter.
- Demonstrated toolboxes for generating optimal portable Fast Fourier Transforms and wavelet algorithms and applied them to high dimensional synthetic aperture radar.
- Developed mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in thin film process simulations and signal processing applications.

• Advanced Mathematics for Microstructural Process Control. ($ 6.113 Million)
  - Developed physicochemical models for thin film vapor deposition process that integrate process, sensing, and control considerations and provide understanding of critical microstructure issues needed to design high-quality and high-yield manufacturing processes.
  - Implemented fast algorithms for modeling and design of large-scale, high-performance electronic circuits.
  - Developed reduced order physicochemical models and algorithms for real-time sensing and control of thin film vapor deposition processes.

• Precision Optics Technology. ($ 5.455 Million)
  - Continued development of conformal optical system components for tactical systems.
  - Completed designs of conformal optics sensor systems and down selected demonstration candidate (missile seeker dome).
  - Fabricated aspheric optical components and diffractive optical elements on curved substrates.
  - Demonstrated metrology tools.

• Miniature Air-Launched Decoy (MALD). ($ 17.920 Million)
  - Fabricated and delivered flight-test vehicles.
  - Conducted flight readiness review.
  - Continued ground testing and initiated Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) flight-testing.
  - Began ground and flight maintenance training and began flight test training.
  - Initiated Seek Eagle process.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

- Explored other advanced concepts and supporting technologies for low cost Miniature Air-Launched Decoy (MALD) airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, and jamming.

- Affordable Rapid Response Missile Demonstration (ARRMD). ($ 6.553 Million)
  - Conducted missile concept development, including manufacturing process definition, propulsion integrated flowpath demonstration and manufacturing demonstration.
  - Defined flight-test plan.
  - Began affordability assessment.
  - Performed mission assessment.
  - Evaluated advanced combustor technologies.
  - Conducted system studies related to rapid response weapons effectiveness using various stand-off targeting systems and technologies.

- Evaluated feasibility of high speed launch of small payloads. ($ 0.800 Million)

(U) **FY 1999 Plans:**

- Compact Lasers. ($ 3.600 Million)
  - Demonstrate room temperature long wavelength laser diodes in the 7-to-9 micrometer wavelength range.
  - Complete demonstration of compact high power tunable lasers and lasers diodes at mid-infrared wavelength.
  - Develop packaged tunable mid-infrared lasers for airborne infrared countermeasures.

- High Performance Algorithm Development. ($ 11.800 Million)
  - Validate prototype electromagnetic scattering models for objects in ground clutter.
  - Demonstrate data, sensor, and algorithm fusion algorithms for signal and image processing applications that exploit the feature extraction capability of wavelets.
  - Demonstrate fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
  - Demonstrate feasibility of mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in complex physical process simulations.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

- Advanced Mathematics for Microstructural Process Control. ($ 6.022 Million)
  - Develop algorithms for fundamental chemical calculations that allow treatment of larger systems and more extended phenomena in thin film deposition.
  - Develop multiresolution homogenization techniques to reduce systems of partial differential equations to equations amenable to process optimization and design of control algorithms.
  - Validate island dynamics mathematical model and level set methods for epitaxial growth.

- Precision Optics Technology. ($ 6.283 Million)
  - Continue development of conformal optical systems components.
  - Demonstrate near net-shape growth of conformal windows.
  - Laboratory assembly, demonstration and test of conformal sensor system for missile applications.

- Miniature Air-Launched Decoy (MALD). ($ 9.022 Million)
  - Continue operational demonstrations; acquire limited flight clearance (Seek Eagle); fabricate thirty-two operational test assets and transition to Services.
  - Complete feasibility study to validate that a low cost interceptor derivative can be developed from a MALD. Establish preliminary and final design after cost and performance trades. Determine seeker design options and turbine engine integration.
  - Continue to explore other concepts for low cost MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 10.732 Million)
  - Complete propulsion integrated flowpath and manufacturability demonstrations.
  - Conduct vehicle force and moment testing.
  - Conduct Warfighting Analysis Lab exercises.
  - Complete system preliminary design.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Refine unit cost estimate.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

- Rapid Domination. ($ 0.400 Million)
  - Exploratory study to examine the concept of rapid dominance. This study will analyze the impact of a very rapid and punitive military response to an adversary's aggression.

(U) **FY 2000 Plans:**

- Precision Optics. ($ 6.000 Million)
  - Complete assembly and test of conformal optics Stinger missile dome to quantify performance improvements.
  - Laboratory assembly and test of conformal optical system for airborne applications.
- High Performance Algorithm Development. ($ 8.831 Million)
  - Demonstrate utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
  - Develop advanced mathematical algorithms for high throughput hyperspectral infrared imaging.
  - Validate fast algorithms for electromagnetic scattering at subwavelength scales and of rough surfaces.
  - Develop codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.
- Advanced Mathematics for Microstructural Process Control. ($ 2.936 Million)
  - Construct and test control/optimization codes for sputtering and molecular beam epitaxy reactors.
  - Extend level set methodology to complex diffusion processes in thin film processing.
- Miniature Air-Launched Decoy (MALD). ($ 1.951 Million)
  - Continue operational assessment exercises with thirty-two test assets to support transition to Air Force.
- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 12.365 Million)
  - Continue propulsion ground testing of scramjet.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Continue low-cost manufacturing development. Demonstration of full-scale airframe sections.
  - Complete critical design review (CDR).

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- Complete flight test plan for first flight articles.
- Continue warfighter assessment.

(U) **FY 2001 Plans:**

- Precision Optics. ($ 3.783 Million)
  - Complete assembly and test of a conformal optics sensor system on an airborne platform to quantify performance improvements.
- High Performance Algorithm Development. ($ 9.698 Million)
  - Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal-processing algorithm.
  - Develop and test algorithms for variable precision filters for adaptive signal processing.
  - Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.
  - Develop algorithms for predicting antenna radiation patterns and scattering, both off of and through inhomogeneous materials and deep cavities.
- Advanced Mathematics for Microstructural Process Control. ($ 2.782 Million)
  - Validate reduced order model and algorithms for sensing and control of thin film vapor deposition processes.
  - Demonstrate advanced molecular dynamics/accelerated molecular dynamics simulation techniques for the growth of multilayer materials.
- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 4.200 Million)
  - Continue low-cost manufacturing development.
  - Continue demonstration of full-scale airframe sections.
  - Initiate fabrication of missile demonstrator based on results of critical design review.
  - Continue exploration of supporting technologies for hypersonic missiles.

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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Cost to Complete	Total Cost
Air-Launched Decoy	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	N/A

PE 0603750D, Advanced Concept Technology Demonstrations

(U) **Schedule Profile:**

Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aeronautics Technology TT-07	19.185	30.694	35.385	35.346	39.168	39.593	45.450	49.291	Continuing	Continuing

(U) **Mission Description:**

(U) Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) will be developed and demonstrated. The capability to accomplish unique military missions as diverse as covert imaging in constrained areas, biological-chemical agent detection and characterization, remote precision mines, and urban battlefield communications enhancement, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, propulsion and lightweight power, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectro-mechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small scale actuators. MAFC technologies combine adaptive control strategies with advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to cause the delay or prevention of fluid flow separation. MAFC technologies will be explored for applications such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

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(U) The Navy and the Marine Corps have a need for an affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicle (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated a program to explore two innovative new vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first concept is an advanced Canard Rotor/Wing (CRW) aircraft which offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control, stability and control, propulsion system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000 nm) and endurance (24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. This program will transition to PE 0603285E in FY00.

(U) The goals of the Advanced Rotorcraft Technology (ART) program are to investigate the merits of various advanced rotorcraft technologies and to conduct technology maturation efforts for two such technologies: face gear, split torque transmissions and variable diameter tiltrotors. Task 1 will consist of design, build, and test of a full scale split torque helicopter main rotor transmission based on face gear technology; a unique gear grinding process that enables production grinding of aircraft quality face gears. Moderate scale test gears have been produced and have satisfactorily endured over 20 million cycles of load testing. The project will culminate in building and cycle testing of a small (250 SHP) transmission. Task 2 will consist of tests and experiments to investigate and mature Variable Diameter Tilt Rotor (VDTR) technology. The tilt rotor concept, as embodied in the V-22 aircraft, and as previously demonstrated in the XV-1 and XV-15 prototype aircraft, attempts to achieve the speed of a turboprop aircraft combined with the vertical takeoff and landing capability of a helicopter. This is accomplished through a mechanism that translates the vertical, lifting plane of a helicopter to the horizontal, thrusting plane of a propeller. The size of the rotor/propeller in the aforementioned applications is compromised between that desired for a lifting rotor (large diameter) and that size desired for a thrusting propeller (small diameter). The VDTR concept is an attempt to optimize both the rotor size and the propeller size by including a mechanism that extends and retracts the diameter of the rotating airfoils. While such a design is theoretically feasible and has been demonstrated in small-scale wind tunnel experiments, the concept involves considerable mechanical complexity and aerodynamic challenge. Task 3 is a development program to create a knowledge base and computer code to analyze the operational merit of advanced rotorcraft technologies such as Variable Diameter Tilt Rotor (VDTR), Face Gears, Microadaptive-Flow Control, and Smart Materials. This study will also address the relative merits of such technologies when applied in short takeoff, vertical landing (STOVL) aircraft as contrasted with vertical takeoff, vertical landing (VTOL) aircraft.

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(U) A new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 10.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles (UCAVs), missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas-turbine and micro rocket engines to 5 cm scale gas-turbine and pulse detonation engines (PDEs). Examples of new mission capabilities may include delivery of very small (200g) satellites to low earth orbit (LEO), light weight, long endurance miniature reconnaissance vehicles, and extended range small scale precision munitions. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Micro Air Vehicles (MAV). ($ 14.040 Million)
  - Conducted design and development of functionally diverse propelled Micro Air Vehicle (MAV) Systems, employing alternative technology solutions, and satisfying user-identified critical military applications. Identified and initiated development of key flight enabling technologies. Continued evaluation of operational MAV concepts.
  - Conducted studies of Micro Adaptive Flow Control (MAFC) technology feasibility in the context of selected system applications, including micro air vehicle flight controls and small scale aerodynamically steerable munitions, aspirated gas turbine compressors, inlet duct flow control, rotorcraft and tilt rotor vehicles. Initiated assessment of actuator effectiveness, scaling, and fabrication methodologies.

- Initiated system design, component tests, and flight control simulations for the Canard Rotor Wing and A160 vertical take-off and landing (VTOL) unmanned air vehicle (UAV) concepts. Completed major structural analysis effort to prove feasibility of main rotor system concept. Design of A160 main rotor blades, hub and main gearbox test components complete and released for bids and/or tooling. ($ 5.145 Million)

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(U) **FY 1999 Plans:**

- Micro Air Vehicle (MAV). ($ 12.912 Million)
  - Conduct Micro Air Vehicle (MAV) system development and fabrication. Continue exploration and demonstration of flight enabling technologies and subsystems. Initiate flight test planning for propelled rotary-wing and fixed-wing reconnaissance vehicle systems incorporating operational templates, design flight capabilities, and mission characteristics. Initiate advanced MAV concept definition.
  - Conduct assessment of small-scale air-breathing and rocket propulsion systems. Systems to be evaluated include micro-turbojet and micro-rocket engines, pulsed combustor engines, and miniature gas turbine and pulse-detonation engines. Initiate development of selected Small Scale Propulsion Systems.

- Complete studies of Micro Adaptive Flow Control (MAFC) feasibility for high work compressors, aerodynamically steerable munitions, and rotary and tilt wing hover vehicles. Initiate development and demonstration of MAFC actuator and controller technologies for system-relevant flow conditions. ($ 5.689 Million)

- Complete detailed designs, analyses, simulations and component tests and begin fabrication of Canard Rotor Wing and A160 demonstrator aircraft. Conduct engineering, endurance and ground tests. Begin fabrication of two Canard Rotor/Wing (CRW) demonstrators and three A160 demonstrators. ($ 12.093 Million)

(U) **FY 2000 Plans:**

- Complete development of flight enabling technologies for micro air vehicles. Complete flight demonstration of the hovering Micro Air Vehicle (MAV) system, and complete fabrication and flight test of the fixed wing MAV system. Continue concept of operations evaluation for military use. Incorporate autopilot into rotary wing MAV. ($ 11.403 Million)

- Continue Micro Adaptive Flow Control (MAFC) actuator and controller development. Assess actuator and control system performance, control authority, bandwidth and power requirements. Integrate MAFC technology into feasibility demonstration systems for selected military applications, including high-work compressors, adaptive munitions, and fixed-and rotary wing air vehicles. ($ 11.705 Million)

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- Complete detailed design of several small-scale propulsion systems. Begin fabrication of selected small-scale propulsion systems. ($ 5.877 Million)

- Conduct Advanced Rotorcraft Technology (ART) assessments and technology maturation. Conduct vehicle configuration trades and develop aircraft synthesis codes to investigate the relative merits of short takeoff, vertical-landing rotorcraft as contrasted with traditional vertical takeoff, vertical landing rotorcraft. Begin design and construction of an AH-64 size test transmission using face gear technology. Construct large scale test hardware and begin reliability testing of extension/retraction mechanisms to enable variable diameter tilt rotors. ($ 5.400 Million)

- Conduct technology assessments and feasibility testing of advanced aeronautic concepts, including supersonic laminar flow, air-to-air resupply and continuous aerodynamic control surfaces. ($ 1.000 Million)

(U) **FY 2001 Plans:**

- Complete advanced Micro Air Vehicle (MAV) development including system fabrication and flight-testing; complete military concept of operation evaluation and complete transition of MAV systems to services. ($ 5.046 Million)

- Continue Micro Adaptive Flow Control (MAFC) technology development and validation tests. Initiate studies to integrate MAFC technologies into full-scale engine, munition and aircraft systems. Initiate demonstration plan, including flight and field tests of integrated MAFC systems. ($ 13.000 Million)

- Design and fabricate selected small-scale propulsion subsystems and fabricate integrated flight-ready propulsion system prototypes. Conduct subsystem checkout and initial system tests and demonstrations. ($ 10.000 Million)

- Advanced Rotorcraft Technology (ART): Conduct rig testing of an AH-64 size face gear helicopter transmission. Complete reliability testing of extension/retraction mechanisms for variable diameter tiltrotors and begin wind tunnel testing of a 1/3-scale variable diameter tiltrotor. ($ 5.700 Million)

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- Perform concept of operations analysis, technology evaluation and feasibility assessment of micro ballistic missiles for military utility. ($ 1.600 Million)

(U) **Other Program Funding Summary Cost:**

FY 1998 $5.6 Million of Defense Airborne Reconnaissance Office (DARO) funding provided for Canard Rotor Wing (CRW) concept demonstration.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-10					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Logistics Technology TT-10	20.685	20.853	10.352	10.000	16.800	16.800	16.800	16.800	Continuing	Continuing

(U) **Mission Description:**

(U) The Advanced Logistics Project will investigate and demonstrate technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts cannot be accomplished today. The Advanced Logistics Project will address these shortcomings and enable this significant capability to be developed. In addition, the project has enormous potential for cost savings through greatly improved management of transportation and logistics assets.

(U) This project will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan as the situation requires, even while assets are enroute to the theater. The Advanced Logistics Project will focus on the following three areas: 1) Development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) Automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) Development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure. The capabilities from these three areas will be integrated to demonstrate a prototype end-to-end system solution.

(U) The Advanced Logistics Project supports Joint Vision 2010, US Transportation Command and Defense Logistics Agency initiatives, and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately transition to other joint

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initiatives which include the Defense Logistics Agency's Logistics Research and Development Demonstration (PE 0603712S), the Joint Logistics Advanced Concept Technology Demonstration (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Developed and demonstrated the automated generation of a portion of a logistics plan for a major force deployment from home station to the port of embarkation across a distributed environment involving 5 different locations. ($ 7.700 Million)
- Initiated development of plan deviation detection sentinels and predictive analysis to assist in identification of replanning opportunities. ($ 3.500 Million)
- Continued development of advanced software data collection techniques. Initiated development of a Dynamic Critical Items List for sustainment planning and execution. Continued development of multi-echelon collaborative logistical support technologies. ($ 9.485 Million)

(U) **FY 1999 Plans:**

- Demonstrate an integrated environment to support the planning, execution and monitoring of a unit deployment from point of debarkation through in-theater distribution, including automated infrastructure assessment and monitoring. ($ 9.050 Million)
- Develop and demonstrate the ability to negotiate the exchange of information between suppliers and buyers, including rapid, flexible item and item relationship catalogs for automated sustainment processing. ($ 4.850 Million)
- Develop automated deviation detection and triggering of the replanning processes. Continue development of a Dynamic Critical Items List for sustainment planning and execution. Develop and demonstrate automated medium grained course of action evaluation that is linked to the war plan. ($ 6.953 Million)

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(U) **FY 2000 Plans:**

- Develop capability to automatically plan and schedule movements from installation to the theater of operations and integrate the resulting movement plan with operations within the theater. Demonstrate capability for users to visualize multiple facts of the transportation schedule. ($ 2.639 Million)
- Develop capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies. ($ 3.307 Million)
- Develop capability to automatically notify users when projected completion of an executing task differs from planned timeline. ($ 4.406 Million)

(U) **FY 2001 Plans:**

- Develop capability to automatically build and compare logistics plans in support of four operational courses of action in four hours. ($ 6.400 Million)
- Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations. ($ 3.600 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-11					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Logistics, TT-11	9.790	9.633	9.736	10.000	10.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Joint Logistics project is a multi-part Advanced Concept Technology Demonstration (ACTD) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Global Combat Support System (GCSS). The focus area for Part 1 (Joint Logistics ACTD) corresponds to Commander-in-Chief (CINC) and Service requirements to develop JDST capability in the areas of Force Capability Assessment; Logistics Support Concepts and Plan Generation; Distribution, Materiel Management, Maintenance Analysis; and Visualization. Part 2 (Joint Theater Logistics ACTD) integrates and extends those capabilities to provide real-time in-theater management and analysis (ITMA) tools. JDSTs will use maturing technologies to provide warfighters and logisticians with the abilities to: assess support force capabilities to perform mission tasks; develop and evaluate logistics operational support plans; and, monitor logistics operations and react to deviations from projected support. These tools will exploit near real-time logistics data sources and will be available to all users via a web-based client server environment that complies with defense information infrastructure (DII) common operating environment (COE) architecture standards and requirements. ITMA tools will provide the fusion and correlation of plans and information for critical components of the in-theater support, sustainment and transportation system providing effective management, analysis and situational awareness to the logistics commanders. The ITMA capabilities will include real-time interoperability support between logistics, operations and intelligence force components. Key data sources include Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), the Global Transportation Network (GTN), the Joint Operational Planning and Execution System (JOPES), and the Global Status of Readiness and Training System (GSORTS). This project will also provide a migration path for evaluating advanced technologies that are being developed by other projects such as the DARPA Advanced Logistics Technology Project (TT-10). These ACTDs will support CINC/Joint Task Force (JTF) and Service/Agency logisticians across the entire operational spectrum -- mobilization, deployment, employment, sustainment and redeployment.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Part 1
  - Defined operational architecture and network requirements for employment of joint decision support tools for CINCs, Components, and Services that operate within the GCSS environment and exploit near real-time data feeds (JTAV, JPAV, GTN, etc.) into a common operating picture between operations and logistics. ($ 3.100 Million)
  - Designed, developed, and migrated an initial set of web-based joint decision support tools. ($ 5.590 Million)
  - Finalized plans to demonstrate access to Joint Decision Support Tools (JDST) within the Global Combat Support System (GCSS) environment in a joint warfighting exercise. ($ 1.100 Million)

(U) **FY 1999 Plans:**

- Part 1
  - Develop data access and mediation capability to pull information from disparate data sources and to share data and JDST data products between applications through a common user interface. ($ 2.875 Million)
  - Expand tool set functionality focusing on Component and Service needs. Derive and graphically display planned force capability estimates for logistics units throughout the deployment sequence at specific nodes over time. ($ 2.875 Million)
  - Determine, evaluate, display, and compare logistics support concepts to include unit capabilities and select supply class requirements to support one or more operational courses of action. ($ 2.383 Million)

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- Transition proven tools through the DARPA/Defense Information Systems Agency (DISA) Advanced Information Technology Services (AITS) Joint Program Office (JPO) into GCSS. Demonstrate the capabilities to provide a qualitative force capability assessment and generate a logistics support force structure for CINC/JTF use. ($ 1.500 Million)

(U) **FY 2000 Plans:**

- Part 1

  - Expand development of Joint Decision Support Tools (JDSTs) to compare planned logistics unit support capabilities with actual capabilities at specific nodes over time. ($ 4.868 Million)
  - Exercise and demonstrate advanced JDST capabilities in an expanded joint warfighting exercise. ($ 1.000 Million)

- Part 2

  - Expand JDST to integrate in-theater distribution support planning and infrastructure assessment to generate and compare alternative logistics support force concepts to support multiple operational courses of action. ($ 2.000 Million)
  - Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistics activity for select support items by location, provider, and intended consumer. ($ 1.868 Million)

(U) **FY 2001 Plans:**

- Part 2

  - Develop capability to calculate in-theater support unit requirements and sustainment and identify matching sources to meet mission requirements. Track the execution of that sourcing and sustainment from closure through dissemination through the theater. ($ 4.000 Million)

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- Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. Develop a real-time in-theater management capability for critical resources like fuel and munitions, which integrates executing logistics plans with logistics and operational data feeds. ($ 3.500 Million)
- Develop and demonstrate the capabilities to access commercial and direct vendor data sources, and to interface with Automatic Identification Technology System products. Develop and demonstration the fusion of disparate data sources to provide real-time tracking and visibility for both strategic and commercial in-theater movements. ($ 1.000 Million)
- Demonstrate multi-echelon interoperability and in-theater management capabilities in a joint warfighting exercise. ($ 1.500 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E, R-1 #17					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	43.994	39.607	31.296	32.000	0.000	0.000	0.000	0.000	0.000	N/A
High Definition Systems IC-03	43.994	39.607	31.296	32.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high-resolution images.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishmnts:**

- Continued development of large organic-based display technologies and systems for command and control applications, including laser based projection. ($ 9.300 Million)
- Continued development of equipment and components to meet display cost and performance goals. This included efforts in printing and microreplication, field emission display materials, organic light emitting materials, phosphor technology development and support for the domestic display-manufacturing infrastructure. ($ 23.600 Million)
- Completed high definition optoelectric digital camera development. ($ 1.900 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E

- Initiated display glass manufacturing development. ($ 3.700 Million)
- Continued development of system prototypes, leveraging previously developed display technologies, particularly for mobile displays and incorporated integrated systems and intelligent interfaces. ($ 5.494 Million)

(U) **FY 1999 Plans:**

- Complete development of large organic-based and inorganic display technologies and continue development of flexible substrate displays for command and control applications. ($ 15.500 Million)
- Continue development of equipment and components to meet display cost and performance goals. This will include efforts in printing and microreplication, field emission display materials, organic light emitting materials and phosphor technology development. ($ 6.000 Million)
- Apply and demonstrate field emission components in Flexible Emissive Displays for large area high resolution, rugged displays for DoD applications. ($ 6.660 Million)
- Complete first generation integrated display systems and system prototypes for mobile applications. Continue development of large screen command and control system prototypes, to include development of a large area, high resolution. ($ 11.447 Million)

(U) **FY 2000 Plans:**

- Develop flexible, rugged displays based on organic electroluminescence and zero-power reflective technology. ($ 3.430 Million)
- Develop active matrix backplanes on flexible substrates for high performance/low power rugged displays. ($ 8.000 Million)
- Develop enhanced maturing technologies (organic electroluminescence, field emission and flexible field substrates) to performance capabilities required for DoD applications. ($ 6.000 Million)

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- Develop roll-to-roll processing for inexpensive flexible rugged displays for DoD applications. ($ 11.736 Million)
- Demonstrate/insert display technology into DoD systems to evaluate display technology. ($ 2.130 Million)

(U) **FY 2001 Plans:**

- Demonstrate large area, high resolution and flexible rugged roll-up display. ($ 12.000 Million)
- Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. Integrate Field Emission and Phosphor Display Technologies. ($ 4.200 Million)
- Evaluate new display concepts for large, high-resolution displays. ($ 13.800 Million)
- Demonstrate/insert display technology into DoD systems for display evaluation. ($ 2.000 Million)

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY2000	FY2001
Previous President's Budget	45.695	34.000	32.000	32.000
Current Budget	43.994	39.607	31.296	32.000

(U) **Change Summary Explanation:**

FY 1998	Decrease reflects reprogramming to the Small Business Innovation Research program in keeping with statutory direction.
FY 1999	Increase reflects congressional increase for flat panel display technology, partially offset by undistributed reductions.
FY 2000	Decrease reflects minor program repricing.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, R-1 #18

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	213.386	278.286	235.321	219.063	211.285	209.275	224.071	243.594	Continuing	Continuing
Materials Processing Technology MPT-01	123.603	169.416	111.419	126.512	135.523	135.972	141.054	150.895	Continuing	Continuing
Microelectronic Device Technologies MPT-02	60.972	87.801	97.356	71.216	60.594	63.358	73.215	83.056	Continuing	Continuing
Cryogenic Electronics MPT-06	17.549	18.164	26.546	21.335	15.168	9.945	9.802	9.643	Continuing	Continuing
Military Medical/Trauma Care Technology MPT-07	11.262	2.905	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-0l) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, protective coating materials to eliminate environmental hazards, infrared artificial dielectrics, development of bio-interface materials and methods, energy harvesting

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concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD sensor, robotic, etc. applications.

(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology.

(U) In the Cryogenic Electronics project (MPT-06), thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

(U) **Program Change Summary:** (*In Millions*)	**FY1998**	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	231.353	244.408	234.218	250.208
Current Budget	213.386	278.286	235.321	219.063

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(U) **Change Summary Explanation:**

FY 1998 Decrease reflects DD1415 transfers of LSTAT program to Army, Defense Microelectronic Activity to the Defense Logistic Agency, transition of the Advanced Biomedical Technology program and inflation adjustments.

FY 1999 Increase reflects congressional adds for Seamless High Off-Chip Connectivity (SHOCC); laser diode arrays; nanophase magnetic materials; strategic materials manufacturing; and polymer materials programs.

FY2000-01 Changes reflect expansion of efforts in VLSI photonics, silicon RF and integrated fluidic cooling developments offset by transfer of Biowarfare related portions of the Biomimetic Systems program to PE 0602383E.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials Processing Technology MPT-01	123.603	169.416	111.419	126.512	135.523	135.972	141.054	150.895	Continuing	Continuing

(U) **Mission Description:**

(U) The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and/or enable new missions for military platforms and systems.

(U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, and multi-functional materials for lowering the weight and increasing the performance of aircraft and spacecraft structures. Approaches are also being developed for reducing the risk of using new materials in defense acquisitions. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters, and submarines. "Intrinsically smart" materials that provide self-diagnosis and/or self-repair will be developed as well.

(U) A second major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators, and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored.

(U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors, mesocoolers, and meso air and water purification for the individual soldier. Technology for the mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of both active and passive components, significantly reducing the size, weight, and cost of integrated electronics functions (batteries, antennae, etc.).

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(U) New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power for soldiers and sensors from the environment. Infrared Artificial Dielectrics (IRADs) are a new class of infrared materials having an emissivity that can be fully engineered for different spectral bands. Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Structural Materials and Devices. ($ 29.703 Million)
  - Demonstrated low cost titanium and superalloy component fabrication processes.
  - Demonstrated uniformly bonded face sheet attachment on ultra lightweight foamed metal structures.
  - Demonstrated a 5x reduction in prototyping time (print-to-part) for ceramic and metal gas turbine engine components utilizing solid freeform manufacturing.
  - Demonstrated a laser workcell at a beta test site.
  - Established approaches for breakthrough gains in personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round) through the application of innovative materials, materials processing and phenomenological modeling of multicomponent materials systems.
  - Initiated mesoscale machine demonstrations of interest to the DoD including a miniature air pump and a micro-cooler.
  - Evaluated an Al-Be F-15 rudder spar.
  - Evaluated structurally porous, ultra-lightweight aircraft panels.
  - Completed the fabrication and evaluation of nanostructured, hard carbon coatings with high adhesion, low friction, high hardness and high wear resistance.

- Smart Materials and Actuators. ($ 24.700 Million)
  - Demonstrated a fabrication process for microintegrated smart materials.
  - Demonstrated full size, smart material active helicopter blade structure and acoustic noise suppression structure on a rotor test stand.
  - Evaluated the actuation potential of magneto-elastic and magneto-shape memory transducer materials.

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- Evaluated high performance electroceramic actuator fabrication processes.
- Demonstrated the applicability of a smart shape adaptive wing to vortex destabilization in hydrodynamic applications.
- Designed, built, tested and evaluated high power laminated actuator stacks for smart defense structures utilizing Computer Aided Manufacturing-Laminated Engineering Materials (CAM-LEM) solid freeform fabrication capability.

• Functional Materials and Devices. ($ 48.000 Million)
  - Demonstrated a prototype giant magneto-resistive (GMR) magnetic memory array and spin transistor memory cell array using magnetic multilayers.
  - Developed microstructural models for prediction of GMR thin film properties.
  - Designed and built a very high sensitivity magnetometer.
  - Continued polymer development using advanced lithography techniques for infrared artificial dielectrics (IRADs).
  - Demonstrated electroactive optical flow characteristics of polymers.
  - Initiated effort to reduce loss tangent in ferrites and ferroelectric oxides for frequency agile RF components.
  - Demonstrated a switched circulator and phase shifter using thick film ferrites.
  - Selected model systems for establishing the structure, chemistry, and function of biotic/abiotic interfaces and biological systems which provide the capability to design biological and biohybrid devices of interest to the DoD (e.g., sensors, smart membranes, actuators, etc.).
  - Demonstrated high-density electronic interconnects for Seamless High Off-Chip Connectivity (SHOCC) interposer.

• Energy and Environmental Sciences. ($ 21.200 Million)
  - Developed balance-of-plant and packaging for a direct oxidation fuel cell replacement for military standard batteries.
  - Demonstrated that full scale, intelligent processing of copper-indium diselenide (CIS) solar cells yields both performance and cost (<$1/watt) suitable for use of flexible photovoltaics in military operations.
  - Developed energy harvesting and storage concepts for unattended devices.
  - Demonstrated the utility of advanced erosion/corrosion resistant thin film coatings at a military site.
  - Demonstrated intelligent processing of thermal barrier coatings yielding reliable coatings, which increase turbine engine inlet temperatures by up to 200 degrees F, with a commensurate increase of 10-15% in thrust.
  - Demonstrated effective silicon-based fouling release coatings for military vessels that offer the potential for maintenance free, cost-effective, non-toxic alternatives to existing anti-fouling paints.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

(U) **FY 1999 Plans:**

- Structural Materials and Devices. ($ 32.500 Million)
  - Fabricate and test materials and materials systems concepts designed to significantly improve personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round), dramatically increasing protection for the individual soldier.
  - Demonstrate solid freeform fabrication of titanium forging blanks.
  - Demonstrate spray forming of superalloy forging billets.
  - Demonstrate the use of solid freeform fabrication to upgrade distressed turbine vanes in man-rated gas turbine engines with ceramic composite components of high reliability.
  - Demonstrate initial feasibility, fabrication and performance of prototype mesoscale machines and components (e.g., miniature air blower, microcooler, meso pump, water purifier, etc.).
  - Demonstrate capability of sub-scale mesoscale pumping chambers to meet full-scale air blower design requirements.

- Smart Materials and Actuators. ($ 28.516 Million)
  - Demonstrate vortex wake reduction for submarines using smart materials.
  - Evaluate submarine acoustic noise reduction using smart materials pads and tiles.
  - Demonstrate a full-scale shape adaptive fighter inlet.
  - Establish growth conditions for large piezoelectric single crystals from flux using both open and closed crucible techniques.
  - Evaluate the impact of piezoelectric single crystals on Navy low-frequency surveillance sonar, mid-frequency navigation/tactical sonar, and high-frequency weapons guidance sonar.

- Functional Materials and Devices. ($ 62.800 Million)
  - Demonstrate high speed, radiation hardened, medium density, and non-volatile magnetic memory utilizing magnetic multilayers; develop methods for controlling the microstructure of these giant magneto-resistive (GMR) films during growth.
  - Demonstrate very high sensitivity magnetometer and gradiometer for localization of magnetic anomalies.
  - Demonstrate a permanent magnet material with a 50 percent higher strength (energy product).
  - Expand the use of solid freeform fabrication to demonstrate a new process for the fabrication of silicon carbide devices and simple electronic component parts using rapid tool-less deposition processes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Complete polymer development for infrared artificial dielectrics (IRADs).
- Demonstrate the actuation capability of polymeric muscles.
- Demonstrate a loss tangent less than 0.002 in hybrid ferrite/ferroelectric frequency agile filters.
- Demonstrate a voltage-controlled oscillator (VCO) with an octave tuning range and low loss. Demonstrate scale-up capability for single crystal growth utilizing x-ray interference patterns to template crystal growth.
- Demonstrate enhanced biological responses (molecular, cellular and organismal) at modified material interfaces. Identify approaches for the neurological control and behavior of simple biological systems through biomaterial development.
- Demonstrate actuator materials and bioinspired control strategies for biomimetic locomotion systems; develop biomimetic systems that incorporate extremophile strategies for enhanced stability and performance in the environmental extremes required by the DoD.

- Energy and Environmental Sciences. ($ 24.600 Million)
  - Demonstrate a low temperature, packaged direct oxidation fuel cell for soldier applications.
  - Demonstrate alternative energy sources (including thermal energy conversion) for soldier microclimate cooling and for portable battery chargers.
  - Demonstrate energy harvesting concepts from ambient sources for unattended sensor applications.
  - Investigate fate and transport of chemicals in soil as well as chemotaxis schemes for localization of sources.
  - Demonstrate approaches to augment portable power sources by recovering energy from human activity.
  - Complete demonstration and insertion of advanced erosion/corrosion resistant and anti-fouling thin film coatings in military systems.

- Congressionally mandated program for Seamless High Off-Chip Connectivity (SHOCC). ($ 5.000 Million)
  - Demonstrate the SHOCC concept in an advanced signal processor device in which a flip-chip digital signal processor will be bump bonded to an interposer layer.

- Congressionally mandated program for the development of laser diode bar mounting techniques in laser diode arrays. ($ 3.000 Million)

- Congressionally mandated program for the continuation of research at the Advanced Materials Research Institute to demonstrate nanostructured magnetic materials for enhanced density magnetic media. ($ 7.000 Million)

- Congressionally mandated program for Strategic Materials Manufacturing. ($ 2.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Congressionally mandated program for the continued development of polymer materials and processing. ($ 4.000 Million)

(U) **FY 2000 Plans:**

- Structural Materials and Devices. ($ 20.100 Million)
  - Integrate material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
  - Develop analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in defense acquisitions.
  - Investigate concepts for the use of multifunctional materials in Defense applications (e.g., blast protection, thermal control) based on successes in ultra-lightweight metals and other structural materials programs.
  - Develop approaches for rapid design, optimization and assembly of small structures and devices based on solid freeform and rapid prototyping technologies.

- Mesoscopic Structures and Devices. ($ 7.000 Million)
  - Demonstrate the operation of a mesoscopic pump array with flow rates over 5 liters/min. in one cubic inch.
  - Build and test an individual integrated mesoscopic cooler.
  - Demonstrate a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
  - Demonstrate the ability to directly write active and passive electronic materials and components at the mesoscale.

- Smart Materials and Actuators. ($ 23.319 Million)
  - Demonstrate improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Develop a "smart skin" for the reduction of self-noise and radiated noise in torpedoes.
  - Explore novel actuator schemes for enhancing the performance of soldiers or devices.
  - Demonstrate techniques to grow large (>3 cm) single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Functional Materials and Devices. ($ 42.400 Million)
  - Demonstrate very fast (<20 nsec access time), high density, radiation hardened magnetic memory circuits utilizing both giant magneto-resistance (GMR) multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrate very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrate permanent magnet materials with 75 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 250 C.
  - Demonstrate a loss tangent less than 0.001 in hybrid ferroelectric/ferrite devices.
  - Demonstrate a broadband 360-degree phase shifter with very low loss for antenna feed applications.
  - Demonstrate polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrate green light-emitting diodes (LED) fabricated from electroactive polymers, with a half-life >5,000 hours; demonstrate blue and red LEDs with >1,000 hours half-life.
  - Select appropriate polymeric materials with electronic characteristics for field-effect transistor (FET) development.
  - Demonstrate growth of AlGaSb-InAs thin films on GaAs substrates using the lateral epitaxial overgrowth technique.
  - Demonstrate lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain-absorbing layers.

- Bioinspired Materials and Devices. ($ 2.400 Million)
  - Explore sensormotory and navigational control schemes for biological systems through microelectronic interfaces.
  - Evaluate chemical, visual, and acoustic cues used by biological systems for controlled locomotion, behavior, and distribution.
  - Evaluate computational neuromechanics and biomechanics of locomotion.

- Advanced Energy Technologies. ($ 16.200 Million)
  - Demonstrate and field test compact portable power systems in soldier applications.
  - Develop high efficiency direct thermal to electric energy conversion.
  - Demonstrate (in the laboratory) power generation from the environment capable of operating unattended ground sensors.
  - Investigate novel concepts for small-scale, near ambient temperature, chemical power generation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

(U) **FY 2001 Plans:**

- Structural Materials and Devices. ($ 20.200 Million)
  - Demonstrate ultra-lightweight armor with 100 percent improvement over current materials and begin transition of manufacturing/design capabilities to the Army.
  - Demonstrate the use of multifunctional materials to provide an order of magnitude improvement in the capabilities of specific defense systems.
  - Continue the optimization of analytical, experimental, and simulation technologies for predicting the properties of advanced materials.
  - Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.

- Mesoscopic Structures and Devices. ($ 12.200 Million)
  - Demonstrate mesoscopic compressor operation that can work against 4 times atmosphere pressure.
  - Demonstrate a mesh of fully functional integrated mesoscopic coolers that exhibit a coefficient of performance >4 and have 1/3 the weight of the smallest normal-scale coolers.
  - Demonstrate that direct-write mesoscale active and passive components have functionality equivalent to discrete surface mount components.
  - Demonstrate the ability to direct-write mesoscale passive components (resistors, capacitors), batteries and patch antennas on conformal surfaces.

- Smart Materials and Actuators ($ 25.500 Million)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to a conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test for rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Develop techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
  - Develop "intrinsically smart" materials that monitor their own state of "health" and repair themselves as required.
  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in an advanced Navy sonar transducer.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Functional Materials and Devices. ($ 44.712 Million)
  - Demonstrate a prototype, very high density (>64 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance (GMR) or spin-dependent tunneling utilizing very low power and low voltage (<2.5 Volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100x smaller than conventional technology.
  - Demonstrate electronic mobility of $>10^{-4}$ cm^2/Vs in electroactive polymeric materials.
  - Demonstrate advantages of polymer based actuators in specific Defense applications (e.g., robotics, sonar).
  - Demonstrate the use of electroactive polymers as thin film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.
  - Fabricate a preamplifier for a millimeter wave radar front end with a 4-dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.
  - Demonstrate the use of twist bonded substrates for integration of an infrared focal plane with integrated read-out electronics.

- Bioinspired Materials and Devices. ($ 7.800 Million)
  - Identify candidates for advanced sensor systems that incorporate biologically inspired concepts including self-calibration, self-healing, variable temperature operation, functionally responsiveness, and mobility.
  - Construct prototype microelectronic interfaces for control of biological systems.
  - Demonstrate millimeter to centimer scale actuators that emulate the locomotion of biological systems.

- Advanced Energy Technologies. ($ 16.100 Million)
  - Demonstrate energy harvesting from the environment for unattended sensor and soldier applications.
  - Demonstrate (in the laboratory) high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop specific approaches for small, chemical power generation that operates at near ambient temperatures.
  - Investigate novel ultra-high energy density power source concepts.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectronic Device Technologies MPT-02	60.972	87.801	97.356	71.216	60.594	63.358	73.215	83.056	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for Optoelectronics, and infrared devices. Areas of emphasis include high performance analog-to-digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This microelectronics development project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities. This project includes a significant effort to develop advanced material and device technology beyond the classical scaling limits of silicon device technology.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Advanced Microelectronics - Chose candidate interconnect/stacking strategies. ($ 2.400 Million)
- Developed SiC materials for High Power Electronic Power Switching Devices in the 250°- 350°C range demonstrating 11/2 inch diameter wafers with less than one micropipe defects per centimeter squared. ($ 1.700 Million)
- Evaluated thermal management strategies for megawatt-class power switch; evaluated approaches for controlling high-power switch with solid-state electronics (monolithic vs. hybrid); demonstrated 1000-V-class SiC switch. ($ 4.600 Million)
- Explored photonic approaches in the throughput of analog-to-digital (A/D) converters. ($ 3.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- Digital Receiver Processor - Continued efforts to develop advanced digital-based processor components based on high-speed semiconductor technologies, such as heterojunction bipolar transistors. ($ 12.000 Million)
- Sonoelectronics - Initiated development of highly effective sonoelectronic actuators and transducers that can be integrated directly with silicon Very Large Scale Integrated (VLSI) circuits. ($ 7.300 Million)
- VLSI Photonics - Demonstrated feasibility of integration of small arrays (4x4) vertical cavity surface emitting lasers with detectors, and identified degradation mechanism for polymer/small molecule lasers and demonstrated photopumped lasing. ($ 11.100 Million)
- Low Power Electronics - Developed circuits and circuits level design tools to reduce power dissipation for variety of circuits and assist in circuits level tradeoffs. ($ 0.900 Million)
- 3-D Microelectronics - Developed and demonstrated key technologies behind a packaging concept that used a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics. ($ 4.600 Million)
- Mixed-Mode Electronics - Initiated mixed-mode electronics multitechnology insertion (MIME). ($ 7.000 Million)
- Nanofabrication - Investigated areas of nanofabrication of electronic devices and extreme ultraviolet (EUV) lithography to be used in the next decade for the fabrication of semiconductor devices, such as nanoelectronics and micromechanical structures. ($ 5.600 Million)
- RF Photonics - Completed feasibility demonstration of Radio Frequency Photonics. ($ 0.772 Million)

(U) **FY 1999 Plans:**

- Advanced Microelectronics - Characterize candidate 25-nm transistors $(150nm)^2$ total area and establish process sequence for chip for proof-of-principle demonstration. ($ 8.000 Million)
- Digital Radar Receiver Processor - Develop advanced digital processor components. ($ 11.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- High Power Electronics - Continue development of SiC materials for High Power Electronic Switching Devices increasing water diameter and lowering defect density. Explore new concepts for integration of multiple materials on silicon chips. ($ 4.000 Million)
- Demonstrate high current density (>100 A/cm^2) 1000-V-class SiC high power switch; demonstrate high-temperature (>250 C) operation of a 1000-V-class switch. ($ 7.000 Million)
- VLSI Photonics - Demonstrate integrated 8x8 VLSI photonics chip (laser, detector and electronics) and optoelectronic modeling tools compatible with electronic CAD tools and demonstrate the feasibility of using molecular self-assembly techniques to position optoelectronic devices with high precision on silicon circuits. ($ 20.000 Million)
- Sonoelectronics - Carry out full sonoelectronic integration, combining surface micromachined transducer arrays, low-noise Complementary Metal Oxide Semiconductor (CMOS) electronic readout, acoustic lens and packaging technology, and low-power display technology to fabricate high resolution underwater imager. ($ 8.000 Million)
- HERETIC - Demonstrate heterostructure integrated thermoelectric (TE) or thermionic devices having the same heat-removal capacity as the best commercial off-the-shelf (COTS) TE coolers; fabricate micro-jets, micro-nozzles or micro-thermionic emitters capable of monolithic integration with Si circuits. ($ 5.000 Million)
- Explore concepts in new device technology for 3-D imaging of targets and lightweight electronically steered lasers. ($ 3.301 Million)
- Initiate silicon Reconfigurable Aperture (RECAP) program. Demonstrate microswitches with very low insertion loss, high isolation, and low actuation voltage. Develop fabrication processes for embedded RF microcomponents on large area substrates. ($ 9.000 Million)
- 3-D Microelectronics - Continue development of key technologies behind a packaging concept that uses a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics. ($ 5.500 Million)
- MEMS Deep Etching – Initiate MEMS Deep Etching project. ($ 7.000 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

(U) **FY 2000 Plans:**

- (RECAP) - Demonstrate capability to produce large arrays of microswitches. Begin development of integration technologies for switch layers with signal distribution layers. ($ 17.648 Million)
- Digital Receiver Technology Program - Demonstrate a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) in FY00 with potential for multiple military applications. ($ 3.956 Million)
- High-powered Solid State Electronics - Demonstrate high-current density (>100 A/cm^2) 2500-V class switch from SiC; demonstrate 2500-V rectifier diode from GaN. ($ 4.934 Million)
- Sonoelectronics - Complete sonoelectronic camera prototype fabrication, and carry out laboratory characterization and test-tank demonstration. Carry out sonoelectronic integration for air-couple arrays including acoustic matching and electronic read-out technologies. ($ 9.705 Million)
- HERETIC - Complete integration of HIT device arrays with bias and control circuitry on GaAs substrates; complete integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates. ($ 10.780 Million)
- Advanced Microelectronics (AME) - Demonstrate circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap. ($ 10.786 Million)
- VLSI Photonics - Develop VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; develop system-level CAD tools. ($ 19.560 Million)
- Heterogeneous Materials Integration on Silicon – Initiate an integration program that develops a tool kit of materials and processes for integration of multiple materials onto a single silicon substrate. ($ 10.987 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP) – Initiate program to begin a major development in photonics, using both wavelengths – wavelength optics – as well as spatial attributes of light – bulk optics. ($ 9.000 Million)

(U) **FY 2001 Plans:**

- (RECAP) - Develop electronic ground plane technology that provides minimal phase shift and high reflectivity. Demonstrate integration processes for all layers and begin development of combined control function for electronic RF aperture. ($ 19.000 Million)
- Sonoelectronics - Integrate advanced transducer and acoustic-lens technologies into prototype camera. Demonstrate lab-proven imager in very-shallow-water (VSW) field setting. Carry out laboratory demonstration of an air-coupled array as an electronically steered microphone array. ($ 6.000 Million)
- HERETIC - Demonstrate HIT devices on GaAs having twice the specific heat-removal capacity as the best COTS TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having 5 times the heat-removal capacity as the best convective air or liquid cooling systems. ($ 10.000 Million)
- VLSI Photonics - Demonstrate SAR processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection. ($ 12.216 Million)
- Digital Receiver Technology - Develop 16 Effective bit, 100 MHz bandwidth A/D converter. ($ 4.000 Million)
- Photonic WASSP – Continue component development, integration, algorithms, architectures and sub-system functionality demonstrations. ($ 11.000 Million)
- Heterogeneous Material Integration – Continue integration of new material and processes into a single silicon substrate that will drive system performance. Demonstrate logic circuits and power amplifiers on silicon. ($ 9.000 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

(U) **Other Program Funding Summary Cost:**

- Not Applicable

(U) **Schedule Profile:**

- Not Applicable

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Cryogenic Electronics MPT-06	17.549	18.164	26.546	21.335	15.168	9.945	9.802	9.643	Continuing	Continuing

(U) **Mission Description:**

(U) Thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include upgraded ship-defense radar (SPQ-9B) with 100X greater detectability of missiles in littoral clutter and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Cryogenics Technologies. ($ 13.612 Million)
  - Demonstrated a fully functional Cryo-Radar, with 103 dB dynamic range, 15 dB greater than present performance, showing capability to detect targets over that range and an ability to address the defense of surface ships to attacking missiles.
  - Demonstrated, in flight test, a multi-band receiver for the Joint Airborne SIGINT (Signals Intelligence) Avionics Family (JASAF) configuration.
  - Demonstrated the ability to detect low-level unintended radiation at ranges exceeding 50 km.
  - Demonstrated an improved analog to digital (A/D) converter employing cryogenic components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06

- Demonstrated a low-cost (less than $2,500), highly reliable (greater than 30,000 hr) Sterling cycle cryocooler that delivers 5 watts at 80K with less than 200 watts of total power.

• Thermoelectric Materials and Devices. ($ 3.937 Million)
- Demonstrated a thermoelectric cooler that provides a reduction in temperature greater than 50°C in a single stage.

(U) **FY 1999 Plans:**

• Cryogenics Technologies. ($ 8.396 Million)
- Insert cryogenic packages in communication transceivers that mitigate electromagnetic interference effects.
- Demonstrate SIGINT (Signals Intelligence) applications in aircraft and on the ground.

• Multitechnology Integration in Mixed-Mode Electronics (MIME). ($ 5.000 Million)
- Demonstrate a tunable bandpass filter in the 800-900 MHz range, using a combination of high-temperature superconductivity and micro-electro-mechanical technologies, with Q>5,000 and frequency shift >5%.

• Thermoelectric Materials and Devices. ($ 4.768 Million)
- Demonstrate thermoelectric coolers that can achieve 100°C cooling in three stages or less as compared to the current seven stages.
- Demonstrate potential benefit of efficient power generation from thermoelectric devices operating at high temperature (>500°C).

(U) **FY 2000 Plans:**

• Cryogenics Technologies. ($ 21.446 Million)
- Develop devices and components, based upon superconducting and other electromagnetic materials that in a cryogenic environment would provide a 5-10X-range improvement over conventional means for detection of low-level signals.
- Complete adaptation of cryocoolers in microelectronics packages for communications transceivers.
- Expand efforts in mixed-mode electronics technology development to include tunable high temperature superconducting filters that preserve high-Q, with 10% tunability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06

- Thermoelectric Materials and Devices. ($ 5.100 Million)
  - Demonstrate thermoelectric coolers that can achieve 100°C cooling in two stages or less.
  - Demonstrate a thermoelectric converter with a factor of two improvements in power generation per unit size.

(U) **FY 2001 Plans:**

- Cryogenics Technologies. ($ 19.220 Million)
  - Fabricate a cryogenic module, operating as a front-end pre-selector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/pre-selector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.
- Thermoelectric Materials and Devices. ($ 2.115 Million)
  - Demonstrate an all solid state cooler (or thermal converter) that is competitive with conventional phase change systems.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-07					
COST (*In Millions*)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Military Medical/Trauma Care Technology MPT-07	11.262	2.905	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The DARPA Combat Casualty Care program has two major segments: (1) Advanced Biomedical Technology (ABT) and (2) Ultrasonic Diagnostic Imaging. The ABT segment exploits DARPA's unique leadership role in the electronics and information sciences to project advanced medical care into the far-forward battlefield area to effect early, successful clinical intervention. This thrust finished in FY98. DARPA worked with the US Army Medical and Material Command to develop lightweight personnel status monitors (PSMs) permitting casualty identification and localization. Additional sensor capabilities were developed through a "smart tee-shirt," called the sensate liner, which is a fabric woven with fiberoptic, piezoelectric, and other fibers with additional microsensors to provide an entire suite of sensors for vital signs and physiologic monitoring. The Life Support for Trauma and Transport (LSTAT) is a portable Intensive Care Unit, which has the capability of monitoring the soldier and sending information to physicians in the rear echelon hospitals during evacuation from the battlefield. LSTAT completed development, received FDA approval, and was transitioned to US Army Medical and Materiel Command.

(U) The Ultrasonic Diagnostic Imaging segment is developing high-fidelity diagnostic imaging primarily for the far-forward battlefield environment. The emphasis of this effort is on enhancing and miniaturizing biomedical applications of ultrasound. For example, in conventional ultrasound imaging, the medium (i.e., human tissue) is inhomogeneous and scatters the signal, which blurs the image. The processes for developing high-resolution imaging will build upon the emerging technology of adaptive acoustics, the displays of which are intuitive and easily interpreted by the combat medic and physician.

(U) This work does not duplicate any efforts of the Military Services or the National Institutes of Health. A Memorandum of Agreement exists between the Army Medical Department and DARPA.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Advanced Biomedical Technology. ($ 6.045 Million)
  - Completed sensor development for Personnel Status Monitor system and transitioned to the Army.
  - Completed microminiaturized oxygen saturation sensor.
  - Developed and integrated the sensate liner's suite of microsensors.

- 3-D Ultrasound. ($ 5.217 Million)
  - Continued development, test and evaluation of 2-D array ultrasound transducer for portable applications.
  - Continued digital signal processing for high-resolution, high signal-to-noise ultrasound image.

(U) **FY 1999 Plans:**

- 3-D Ultrasound Technologies. ($ 2.905 Million)
  - Complete ultrasound enhancements for scattering, deaberration, and beam forming; demonstrate resulting system; and transition to the Services.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

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(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	0.000	19.664	19.000	23.000	5.000	5.986	9.986	Continuing	Continuing
Advanced Aerospace Systems ASP-01	0.000	0.000	19.664	19.000	23.000	5.000	5.986	9.986	Continuing	Continuing

(U) **Mission Description:**

(U) The Advanced Aerospace Systems program element (PE) is budgeted in the Advanced Technology Development Budget Activity because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. This new PE has been created to satisfy an Agency requirement for a dedicated host for aerospace research that has progressed beyond the applied research stage and no longer belongs in the 6.2 based Tactical Technology PE. Two of the three initial programs in FY 2000 are outgrowths of Tactical Technology efforts that were previously budgeted in PE0602702E.

(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program will demonstrate an inexpensive supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities (MALD is funded in FY 1999 from Project TT-06, PE 0602702E). An advanced unmanned air vehicle avionics development effort will be incorporated into the MALI core program due to the required data transmit/receive configuration of the interceptor mission.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated the Advanced Air Vehicle program (AAV) to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design,

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fabrication and flight test of this scaled vehicle concept will be conducted to validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000 nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. The A160 and CRW programs were initiated in FY 1998 under PE 0602702E, TT-07, Aeronautics Technology, but are funded in ASP-01 beginning in FY 2000 in recognition that their technological maturation dictates Budget Activity 3 placement.

(U) The Advanced Space Transportation and Robotic Orbiter (ASTRO) program will develop one or more approaches to "affordably" place small (<100kg) payloads in space for the purpose of servicing, upgrading, or reconfiguring satellites. An important element of ASTRO is the projected economic impact of such capability on current space missions and its potential for enabling new space missions. Phase I program elements will address novel launch techniques (gas guns, small expendable vehicles, small recoverable vehicles); small payload concepts and designs (expandable replacement, subsystem replacement/upgrade, reconfiguration); robotic space operations; and modular, serviceable satellite designs. Given an economically viable and technically achievable approach from Phase I, Phase II will develop needed technologies and demonstrate the concept on orbit.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Not Applicable.

(U) **FY 1999 Plans:**

- Not Applicable.

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(U) **FY 2000 Plans:**

- Advanced Air Vehicle (AAV): Continue fabrication and conduct hardware in the loop and ground testing of Canard Rotor/Wing (CRW) and A160 concepts. ($ 9.503 Million)

- Supersonic Miniature Air-Launched Interceptor (MALI): Conduct engine and low cost miniature sensor testing, fabricate, assemble and conduct ground and early risk reduction testing of air vehicle. Initiate detail test planning for flight demonstration of interceptor and collaborative formation mission. ($ 7.161 Million)

- Advanced Space Transportation and Robotic Orbiter (ASTRO): Conduct assessment and affordability analysis of potential launch concepts; preliminary design of preferred low cost launch systems, including the robotic transfer vehicle; develop test plan for launch demonstration; conduct preliminary design for satellite concepts that enable robotic on-orbit servicing and upgrade; conduct proof-of-concept tests for robotic servicing concepts. ($ 3.000 Million)

(U) **FY 2001 Plans:**

- Supersonic Miniature Air-Launched Interceptor (MALI): Continue fabricate, assemble and conduct ground testing. Perform supersonic engine flight verification and seeker/warhead verification. Conduct Flight Demonstration of supersonic vehicle interceptor and collaborative formation flying mission. ($ 9.000 Million)

- Advanced Space Transportation and Robotic Orbiter (ASTRO): Perform critical design review for preferred launch concept, robotic transfer vehicle, and spacecraft; conduct critical component launch demonstration. ($ 10.000 Million)

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(U) **Program Change Summary** *(In Millions)*

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	0.000	0.000	0.000	0.000
Current Budget	0.000	0.000	19.664	19.000

(U) **Change Summary Explanation:**

FY 2000-01 Increases reflect transfer of the Advanced Air Vehicle and expansion/further application of MALD technologies previously funded in PE 0602702E, and initiation of the Supersonic Miniature Air-Launched Interceptor (MALI) program.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 99	Canard Rotor/Wing (CRW) Critical Design Review.
Nov 99	Conduct Supersonic Miniature Air-Launched Interceptor (MALI) Requirements Definition.
Feb 00	Canard Rotor/Wing Detailed Design Review.
Jan 00	Flight test A160 air vehicle.
Jan 00	Select preferred Advanced Space Transportation and Robotic Orbiter (ASTRO) system concept.

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Jan 00	Perform MALI Critical Design Review after conducting performance trades.
Jan 00	Conduct Preliminary Design Review (PDR) for ASTRO System.
Jun 00	Complete CRW ground testing.
Aug 00	Complete A160 flight control system testbed flights.
Aug 00	Complete ASTRO Flight Test Demonstration Plan.
Sep 00	Conduct ASTRO Proof-of-Concept demonstration.
Nov 00	MALI demonstrates higher thrust output of TJ-50 derivative.
Dec 00	Conduct Critical Design Review (CDR) for ASTRO System.
Mar 01	Demonstrate SLCCMI low cost seeker requirements.
Jun 01	MALI Supersonic Flight Demo.
Sep 01	Complete ASTRO Critical Component Demonstration.

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DATE February 1999

APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defense-wide
BA3 Advanced Technology Development

R-1 ITEM NOMENCLATURE
Advanced Electronics Technologies
PE 0603739E, R-1 #41

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	272.020	265.442	246.023	233.198	232.534	247.767	259.354	258.154	Continuing	Continuing
Uncooled Integrated Sensors MT-03	8.289	12.895	10.791	12.000	7.000	0.000	0.000	0.000	0	N/A
Electronic Module Technology MT-04	65.515	62.985	56.686	41.245	40.849	59.667	63.029	64.829	Continuing	Continuing
Tactical Information Systems MT-05	28.328	30.998	15.605	17.748	18.100	0.000	0.000	0.000	0	N/A
Microwave and Analog Front End Technology MT-06	17.543	3.962	0.000	0.000	0.000	0.000	0.000	0.000	0	N/A
Centers of Excellence MT-07	5.904	6.405	4.000	0.000	0.000	0.000	0.000	0.000	0	N/A
Manufacturing Technology Applications MT-08	26.175	21.991	21.846	4.000	6.000	0.000	0.000	0.000	0	N/A
Advanced Lithography MT-10	49.710	49.362	44.429	45.000	45.000	45.000	45.000	45.000	Continuing	Continuing
Microelectromechanical Systems (MEMS) MT-12	70.556	76.844	70.098	63.350	70.575	93.100	101.325	98.325	Continuing	Continuing
Mixed Technology Integration MT-15	0.000	0.000	22.568	49.855	45.010	50.000	50.000	50.000	Continuing	Continuing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E

(U) **Mission Description:**

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have both commercial and military applications. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the US industrial base.

(U) The Uncooled Integrated Sensors project addresses a long standing Defense requirement for uncooled, solid state advanced infrared sensor arrays for major weapons systems that do not require costly cryogenic cooling packages.

(U) The Electronic Module Technology project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The Tactical Information Systems project contains two major programs: Smart Modules and Warfighter Visualization. Smart Modules is a program to design and develop prototype modules, using core technologies that sense, think and communicate, and integrate them into selected personal information products. Warfighter Visualization is a program to demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters.

(U) The goal of the Manufacturing Technology Applications project is to reduce the cost and acquisition lead time of future military systems by integrating manufacturing process considerations during the product design phase and by demonstrating high efficiency multi-product prototype factories. This project will also enable manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led directly to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability.

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(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards and physiological states.

(U) The goal of the newly established Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Finally, one on-going DARPA project completes in FY 1999: MAFET (MT-06) and another Centers of Excellence (MT-07) completes in FY 2000. The Microwave and Analog Front End Technology (MAFET) project has been directed at significantly reducing non-recurring costs for military microwave/millimeter wave sensor systems through improved computer aided design capabilities. The Centers of Excellence project finances demonstration, training and deployment of advanced manufacturing technologies.

(U) **Program Change Summary:** (*In Millions*)	**FY1998**	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	281.909	244.737	259.014	212.385
Current Budget	272.020	265.442	246.023	233.198

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(U) **Change Summary Explanation:**

FY 1998 Decrease reflects acceleration of MAFET program phase down with anticipated completion by the end of FY 1999 and SBIR reprogramming.

FY 1999 Increase reflects the Congressional adds to the Advanced Lithography, X-Ray Masks, Laser Plasma X-Ray Source Technology, CAMD, NanoTech and Crystalline Arrays and Defense Techlink Center programs.

FY 2000 Decrease reflects completion of the composite CAD program, Smart Module program and reduction associated with inflation.

FY 2001 Increase reflects initiation of the Mixed Technology Integration program and expansion of the Advanced Lithography program.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-03					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Uncooled Integrated Sensors MT-03	8.289	12.895	10.791	12.000	7.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared (IR) sensor arrays, essential to major weapon systems. The focal plane array consists of a two-dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two dimensional sensor array without the cryogenic package usually associated with infrared sensors. Thermal Imaging Devices will develop new imaging at the theoretical limit, (five to fifty times increase over current uncooled devices), achieving high performance in extremely small, low power configurations and demonstrating technology to open new applications for imaging devices.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Demonstrated uncooled infrared array with thermal sensitivity of 0.05 degrees. ($ 3.289 Million)
- Demonstrated low light level solid state imager with anti-blooming protection. ($ 5.000 Million)

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(U) **FY 1999 Plans:**

- Uncooled Integrated Sensors - Demonstrate uncooled infrared array with thermal sensitivity of 0.05° C. Demonstrate low power micro-bolometer sensor for unattended ground sensors. Fabricate and test uncooled infrared array and low power solid state low light level array. ($ 10.572 Million)
- Thermal Imaging Devices - Fabricate and evaluate microstructures with thermal isolation properties five to ten times less than current thermal devices. ($ 2.323 Million)

(U) **FY 2000 Plans:**

- Uncooled Integrated Sensors - Demonstrate 480x640 uncooled with < .05 milli-kelvin, 1 mil pixel. Transfer 480 x 640 uncooled infrared sensor to Army missile seeker program. Field evaluation of high sensitivity uncooled infrared sensor with low light sensor for ground operations. ($ 2.791 Million)
- Thermal Imaging Devices - Demonstrate non-contact read-out devices and characterize sensitivity/noise sources. Demonstrate non-contact imaging array with thermal sensitivity of 100 milli-kelvin. ($ 8.000 Million)

(U) **FY 2001 Plans:**

- Thermal Imaging Devices - Demonstrate 25 gram imaging sensor with performance acceptable for micro-air-vehicles. Optimize read-out structure to read signals with short (approx. 1 msec.) integration time. ($ 12.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Aug 99	Demonstrate feasibility of uncooled infrared array with thermal sensitivity of 0.05° C.
Sept 99	Demonstrate low power micro-bolometer sensor for unattended ground sensors.
Sept 99	Fabricate and test uncooled infrared array and low power solid state low light level array.
Sept 00	Field evaluation of high sensitivity uncooled sensor with low light level sensor for ground operations.
Nov 00	Demonstrate 25 gram imaging sensor with performance acceptable for micro-air-vehicles.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-04					
COST (*In Millions*)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electronic Module Technology MT-04	65.515	62.985	56.686	41.245	40.849	59.667	63.029	64.829	Continuing	Continuing

(U) **Mission Description:**

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The project has four major objectives: (l) shorten the overall design, manufacture, test and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; (3) provide a robust manufacturing infrastructure for electronic modules; and (4) demonstrate the system level payoff of electronic module technology through advanced technology demonstrations (ATDs).

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Optical Micro-Networks (OMNET); Distributed Robotics; Design Support for Mixed Technology Integration (Composite CAD) and the Molecular-Level Large-Area Printing (MLP) program. OMNET seeks to demonstrate new paradigms for integrating electronic, electromechanical and electro-optical components to enable small, lightweight, battlefield information systems. Distributed Robotics is a new effort to integrate developments in MEMS, power sources, communications and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into "systems-on-a-chip" and other highly integrated mixed technology systems. The MLP program is exploring approaches to 'print' MEMS devices on large surfaces.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Completed Application Specific Electronic Modules (ASEM) program that reduced non-recurring engineering costs for designing and inserting multi-chip modules. ($ 5.083 Million)
- Completed the Multichip Integration (MCI) program that improved substrate fabrication, demonstrated reductions in Multichip Modules (MCM) manufacturing costs and technology insertions. ($ 14.300 Million)
- Optical Micro-Networks (OMNET) - Downselected amongst heterogeneous integration technologies and demonstrated multi-functional integration of electronic, electro-mechanical and optoelectric components targeted to military information systems. ($ 12.700 Million)
- Distributed Robotics - Initiated effort to put together, in one package, low-weight (<2 kg), high-performance payloads including sensors, imagers, countermeasures, designators, communications and munitions. ($ 8.800 Million)
- Composite CAD - Integrated a composable design capability for single chip electronics and MEMS systems. Developed models with parameters optimized for manufacturing variances. Initiated behavior modeling of mixed technology devices. ($ 15.900 Million)
- Molecular-level, Large-area Printing (MLP) - Established preliminary micro-molding process using commercially available (CD manufacturing) tool; initiated studies of alternative micro-printing processes (letterpress, gravure, and tropomorphic). ($ 8.732 Million)

(U) **FY 1999 Plans:**

- OMNET - Demonstrate integrated optoelectronic transceivers and optical switches for reconfigurable interconnections of sensors to processors and the ability to distribute computation across military platforms 1-100 meters in length for future Electronic Warfare/digital radar and image processors. ($ 11.000 Million)

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- Distributed Robotics - Construct the unit platforms, integrate commercial or demonstrated technology elements (e.g., imagers, MEMS, wireless systems), and define multiple, cooperative functions for selected military applications. ($ 13.000 Million)
- Composite CAD - Continue to develop the mixed domain software (kinematic, electric, electrostatic, and fluidic) analysis of micro-machined devices, systems of devices and corresponding electronic circuits to support the design of composite electronic sensors and systems. ($ 17.993 Million)
- Photonic A/D - Initiate photonic A/D converter development to achieve breakthrough in high speed A/D conversion. ($ 9.000 Million)
- Molecular-Level Large-Area Printing (MLP) - Complete experimental characterization of release agents for micromolding; select candidate printing processes (≤2) and compatible readout process for development; and demonstrate writing on non-flat surfaces with radii of curvature in the range 1m to 1cm. ($ 11.992 Million)

(U) **FY 2000 Plans:**

- Phototonic A/D - Demonstrate key optical clock, optical sampler and related optical technologies for photonic A/D converters operating in the 10-100 Giga sample per second range and identify high impact applications for this technology. ($ 15.100 Million)
- Distributed Robotics - Demonstrate feasibility of a variety of different robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions. Initiate effort to develop millimeter sized robots. ($ 18.000 Million)
- Composite CAD - Complete the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enabled designs and microfluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip. Provide mixed technology design libraries, models and test structure data to improve design quality, development time and ability to reuse designs. ($ 9.544 Million)
- MLP - Concentrate on the development and choice of non-conventional large-area, MLP techniques for a demonstration system. ($ 14.042 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-04

(U) **FY 2001 Plans:**

- Phototonic A/D - Complete initial photonic A/D converter evaluation and finalize design for demonstration module. ($ 14.500 Million)
- Distributed Robotics - Develop prototype millimeter sized robots using fundamental behavioral control mechanisms for sensing and communicating. ($ 13.000 Million)
- Molecular-level, Large-area Printing (MLP) - Concentrate on the demonstration of the use of MLP for realizing a wide area, super-high-resolution (e.g. 100-megapixel, corresponding to about 1,000 TV images) imaging system as needed, for example, for automatic threat warning. ($ 13.745 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jul 99	Demonstrate mixed energy domain analysis capability for integrated technology devices.
Aug 99	Demonstrate optical micronetwork with reconfiguration capability.
Nov 99	Initial prototype of tightly integrated adaptive payload technology.
Apr 00	Characterization of single crystal semiconductors on amorphous surfaces.
Jun 00	Establish overlay capabilities for MLP.
Sep 00	Design and initiate fabrication of demonstration sensor array.
Sep 00	Demonstrate initial PCM designs (<10-femtosecond jitter, 100 on W output).
Jul 01	Demonstrate and characterize 10,000 x 100-pixel density array on spherical surface.
Aug 01	Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-05					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Tactical Information Systems MT-05	28.328	30.998	15.605	17.748	18.100	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project is a major DoD effort to develop the technology for displays and portable information systems for use in a variety of military systems. The project has two major efforts: Smart Modules and Warfighter Visualization. Smart Modules will design, develop and integrate prototype modules, using core technologies that sense, think and communicate into selected personal information products. Warfighter Visualization efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer-generated information for use by individual mounted and dismounted warfighters.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Demonstrated prototype electronic countermeasures system integrated into a soldier worn vest. The computational capability developed in the FY 1997 program was augmented with two PC cards containing electronic counter measures (ECM) circuitry that allowed dismounted soldiers to instantly locate radio emissions from hostile forces. Demonstrated a prototype waterproof computer for underwater use in Navy SEAL and Explosive Ordnance Disposal applications. ($ 14.200 Million)

- Continued efforts to develop hand and head motion tracking technologies. Tracking head movement will allow a computer to display information to a head mounted display that is registered in the geospatial direction that the individual is looking. Tracking hand motion will allow a computer to recognize pointing and gestures as input mechanisms instead of using a keyboard. ($ 6.400 Million)

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- Demonstrated image capture and geospatial registration of icons on terrain in a moving vehicle. The vehicle was equipped with video cameras that provided a 360 degree view. Inside the vehicle, a person wearing a head tracked, head mounted display was able to look around and view the images obtained from the cameras. Icons and graphical images generated by a computer were overlayed on the camera image in the head mounted display. These images were registered with the viewed real-world terrain. ($ 7.728 Million)

(U) **FY 1999 Plans:**

- Demonstrate a novel capture device that incorporates signal and data processing in a 3-D package for use by individual soldiers. This miniature device, weighing only a few ounces, will be able to capture an image and rapidly analyze movement or correlate images with all processing done on the focal plane. The camera will be able to be worn by individual soldiers and communicate via a radio to and from geographic information system databases. ($ 9.200 Million)

- Demonstrate a wearable computer incorporating wireless communication in a one pound, one watt configuration. This represents a three-fold improvement in weight and a ten-fold improvement in power over current technology. The wearable computer will be used in a wide variety of space applications by the small unit operations soldier. ($ 9.900 Million)

- Demonstrate prototype capability for dismounted soldiers to view the real world with overlayed graphic symbology. This capability will allow the soldier to receive visual information that is relevant to his/her mission time or location. It will also allow the soldier to interrogate databases containing information about the specific objects in his/her viewing environment. ($ 5.800 Million)

- Demonstrate prototype "see-through" tank concept. This capability will allow a "buttoned-up" tank crew wearing head mounted displays to view the outside world as though the tank were made of glass. This will be accomplished by placing cameras on the outside of the tank that provide inputs to a mapped memory. Images will be fed to the user's head mounted display depending upon the direction that the user is looking. This capability will significantly enhance the situation awareness of the tank crew. ($ 6.098 Million)

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(U) **FY 2000 Plans:**

- Warfighter Visualization:
  - Demonstrate a non-metallic tracking system for mounted and dismounted soldiers. System gives accurate low lag estimates of head position and pose for body oriented battlefield visualization. System is necessary for visual data correlation system and see through combat vehicle applications. ($ 3.300 Million)
  - Develop a two-chip image processing system for integration into battlefield smart camera. This system will shrink multiple electronics boards into a small enough package for applications in night vision goggles, UAV surveillance and headworn image stabilization. ($ 4.105 Million)
  - Demonstrate a prototype supernormal listening system for enhanced battlefield awareness. This system will enhance hearing capability and improve situation awareness and voice communications in both quiet and loud ambient noise environments. ($ 3.600 Million)
  - Portable Sensor Datalink – Demonstrate ultra low power, low cost, fully integrated micro-sensor interconnection network technology for harsh battlefield environments. Assure continuous warfighter medical monitoring in the presence of jammers and other interferers using structured noise. Exploit innovations in ultra-wideband technology to provide reliable links to wearable and other instrumented military systems. ($ 4.600 Million)

(U) **FY 2001 Plans:**

- Warfighter Visualization:
  - Demonstrate a two-camera prototype image sensor system giving high resolution imaging over 360 degrees with low delay. This system is essential for the realization of a cost-effective "see through" vehicle. ($ 2.048 Million)

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- Demonstrate an experimental low cost, lightweight perimeter monitoring system for dismounted soldiers. System creates a protection "dome" around sleeping soldiers to alert against intruders. ($ 4.100 Million)
- Demonstrate a prototype, bodyworn, 3-D mission re/planning tool. System allows virtual "walk through" of operations area and real-time editing. System also gives visualization of dynamic multi-sensor I/O on the battlefield. ($ 4.600 Million)
- Portable Sensor Datalink – Develop connection solutions for Condition Based Maintenance automated equipment-monitoring systems to vastly improve safety, increase reliability and reduce costs in military systems. Develop command and control system on-a-chip for miniaturized aerial and ground warfighting platforms. ($ 7.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Dec 99	Build and test Advanced Humanistic Platform prototype.
Dec 99	Develop hybrid sensor tracking features and including "smart camera" functions to allow collaborative updates between soldiers.
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Jul 01	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-06					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microwave and Analog Front End Technology MT-06	17.543	3.962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) Microwave and millimeter wave technology for DoD electronic weapon systems is at a critical crossroads. Great progress has been made under the microwave and millimeter wave integrated circuit (MIMIC) program in terms of maturing the gallium arsenide industrial community. The DoD is now far ahead of the commercial world in microwave and millimeter wave technology in terms of performance characteristics. However, in many cases, radio frequency (RF) sub-system costs are still a major impediment to fielding DoD weapon systems. Material, processes and design technology advances must be undertaken to sustain an effective defense capability and to maintain U.S. dominance in this critical technology area. The MAFET program has addressed this problem by: (1) reducing design time and cost for every RF system being developed or upgraded through an improved microwave/millimeter wave design environment; (2) breaking the very expensive cycle and time-consuming current practice of design-build-test--redesign-rebuild-retest; (3) establishing repeatable, robust processes to produce high frequency components; (4) making strategic investments in critical passive, packaging and integrated circuits devices needed for millimeter wave systems; and (5) investigating revolutionary solutions to the long-standing problem of insufficient power in solid-state radar and communications transmitters.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Completed microwave/millimeter wave computer aided design environment. Demonstrated design environment effectiveness. Continued implementation of Microwave Hardware Description Language (MHDL). ($ 6.000 Million)

- Completed advanced sensor technology developments in the areas of: advanced fabrication, packaging and multichip assembly (MCA) foundries. ($ 5.200 Million)

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- In novel high-power transistor area, demonstrated 5-W SiGe HBT solid-state power amplifier (SSPA) having near-50 percent power-added efficiency (PAE) in X-band; demonstrated 10-W GaN MODFET having PAE=50 percent in X-band; demonstrated 25-W SiC MESFET having PAE=45 percent in X-band. In quasioptics area, continued development of solid-state quasioptical Ka-band sources with high output power and high coherence; completed and demonstrated numerical design tool. In MEMS-switch area, demonstrated 4-bit true-time-delay phase shifter in (a) X-Band with 2-dB total loss, and (b) Ka-Band with 3-dB loss; demonstrated 20/44-GHz dual-frequency MEMS-switched planar antenna. In micromachined circuits and novel thermal management area, demonstrated micromachined W-band Wilkinson combiners in Si substrates; demonstrated Flourinert cooling of a 10-W X-band MMIC and a 1-W Ka-band MMIC. ($ 6.343 Million)

(U) **FY 1999 Plans:**

- In quasioptics area, demonstrate a set of quasioptical grid-, array-, card- and slab-combined power amplifiers. ($ 1.962 Million)
- In MEMS-switch area, demonstrate MEMS-tunable Chebyshev filter operating at 20 and 45 GHz; demonstrate MEMS-array transmitting beam-steerer at 44 GHz. ($ 1.000 Million)
- In micromachined circuits and novel thermal management area, demonstrate a micromachined SSPA ("W-Band Power Cube") having 2 W/in^2 intensity radiated from top facet. The power cube will be fabricated with InP Power MMICs that are thermally managed by bump bonding and are coupled to free space by Si-micromachined feed-line and planar-antenna structures. ($ 1.000 Million)

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Mar 99	Demonstrate millimeter wave beam steering module.
Jun 99	Demonstrate > 100-W low cost X-band electronically steerable source.
Sep 99	Demonstrate full interoperability of CAD vendors.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Centers of Excellence MT-07	5.904	6.405	4.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University and the Defense Techlink Rural Technology Transfer Project. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality. This project also includes funding for the U.S.-Japan Management Training Program whose purpose is to build a growing infrastructure of American scientists and engineers with knowledge about the Japanese R&D enterprise and provide training in the Japanese language.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Completed development of internetting capabilities at the Institute for Advanced Flexible Manufacturing to ensure medium- and small-sized businesses have access to emerging electronic commerce and advanced technologies. ($ 3.804 Million)
- Continued efforts with centers of excellence to support students, researchers and executives to understand Japan's manufacturing infrastructure, culture and language. ($ 1.100 Million)
- Provided funding for the Defense Techlink Rural Technology Transfer Project per Congressional direction. ($ 1.000 Million)

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(U) **FY 1999 Plans:**

- Complete expansion of the Institute for Advanced Flexible Manufacturing's satellite facilities. ($ 3.961 Million)
- Complete efforts with centers of excellence to support students', researchers' and executives' understanding of Japan's manufacturing infrastructure, culture and language. ($ 1.444 Million)
- Provide funding for the Defense Techlink Rural Technology Transfer Project per Congressional direction. ($ 1.000 Million)

(U) **FY 2000 Plans:**

- Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support. ($ 4.000 Million)

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 00	Complete assessment and transition of the Institute from DoD to state/private support.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-08					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Manufacturing Technology Applications MT-08	26.175	21.991	21.846	4.000	6.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible, multi-product factories and if advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50 percent reductions in the unit cost of tactical missiles, in ongoing missile production programs, in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) The goal of the Low Observable Optical Fibers program is to develop low visibility optical fibers that will have the capability of propagating high data rates over significant distances. The objective is to reduce the diameter of the fibers from the current 150/100-micron levels to a 30-micron range while at the same time maintaining 1 Gbits/s transmission rate over a range of 10 kilometers. Potential applications for "invisible" optical fibers are direct hardware connectivity for tactical operation centers and inter-echelon networking. In addition, such technology could provide the intelligence community and/or special operation forces with a covert high-speed link to concealed remote sensors or listening devices.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Affordable Multi-Missile Manufacturing (AM3). ($ 21.372 Million)
  - Began AM3 Phase 3 implementation of new factory systems and new business practices.
  - Completed initial design and test planning for AM3 multi-missile components and value engineering change proposals.
  - Completed initial demonstrations of supply chain technologies to fill gaps identified in AM3 Phase 1.
  - Continued technical integration and independent cost analysis.

- Interferometric Fiber Optic Gyroscope (IFOG). ($ 4.803 Million)
  - Demonstrated flexible production of navigation grade and tactical grade IFOG units.
  - Demonstrated production of high power, stable, packaged optical sources, low cost couplers and wavelength division multiplexers.
  - Improved Magnetic Field and temperature sensitivity of IFOG Instruments further improved packaging and tests for low cost performance.

(U) **FY 1999 Plans:**

- Affordable Multi-Missile Manufacturing. ($ 21.991 Million)
  - Continue AM3 Phase 3 implementation of flexible multi-product assembly cells and prototype production of missile hardware.
  - Conduct initial tests of missile seekers built with the Affordable Multi-Missile Manufacturing scalable family of parts and commercial components.

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(U) **FY 2000 Plans:**

- Affordable Multi-Missile Manufacturing. ($ 19.846 Million)
  - Complete integration of flexible factory assembly areas.
  - Deploy System Integrated Design Environment.
  - Complete design and prototype fabrication of low cost inertial measurement unit (IMU).
  - Complete common processor design verification test and integration.
  - Validate electronic collaborative tools and complete supplier affordability demonstration.
  - Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstration.
  - Complete common seeker commercial parts test evaluation, producibility analysis and flight test.
  - Complete common IMU design verification test, prototype demonstration unit and technology insertion review.
  - Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
  - Complete electronic procurement and supplier integration demonstrations.

- Low Observable Optical Fibers. ($ 2.000 Million)
  - Develop techniques and capabilities to draw and measure optical fibers on the order of 30-micron range.
  - Conduct perception tests and analysis.

(U) **FY 2001 Plans:**

- Low Observable Optical Fibers. ($ 4.000 Million)
  - Produce fibers for physical testing including optical transmission, bend tensile strength and durability testing as well as investigate fiber deployment mechanisms.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Oct 99	Complete integration of flexible factory assembly areas.
Oct 99	Complete common seeker commercial parts test evaluation, producibility analysis, and flight test.
Dec 99	Complete AM3 Phase 3 multi-missile manufacturing demonstrations.
Jan 00	Deploy System Integrated Design Environment.
Jan 00	Complete common inertial measurement unit design verification test, prototype demonstration unit and technology insertion review.
Mar 00	Complete common processor design verification test and integration.
Mar 00	Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstrations.
Jul 00	Complete electronic procurement and supplier integration demonstrations.
Dec 00	Complete low observable optical fiber production assessment.
Sep 01	Complete low observable optical fiber physical testing.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-10					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Lithography MT-10	49.710	49.362	44.429	45.000	45.000	45.000	45.000	45.000	Continuing	Continuing

(U) Mission Description:

(U) Microelectronics is a key to improved weapon system performance and lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption and weight. Advanced microelectronics technology is essential for computing and signal processing in virtually all military systems including command, control, communications and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1-micron features.

(U) The goal of the lithography program is to reduce technical barriers in the development of advanced lithographic technologies for the fabrication of a broad range of microelectronic devices and structures. Innovative research in pattern generation and transfer, imaging materials, new process and metrology will provide alternatives beyond current evolutionary trends. The program will investigate technologies for the creation of highly-complex patterns at sub 0.10μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics.

(U) Program Accomplishments and Plans:

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(U) **FY 1998 Accomplishments:**

- Researched efforts for sub 0.1 micron in maskless lithography (emitter arrays and photocathodes), innovative imaging materials and network of university efforts in novel patterning. ($ 19.400 Million)
- Completed development of crosscutting technology in precision stages and mask making (e-beam writing and inspection) for 0.13 - 0.10-micron features. ($ 6.200 Million)
- Completed point-source x-ray lithography program. ($ 2.800 Million)
- Continued funding of the Lithographic and Alternative Semiconductor Processing Techniques (LAST) Center to develop mask technology for semiconductor device fabrication. ($ 16.700 Million)
- Continued Laser Plasma x-ray source technology. ($ 4.610 Million)

(U) **FY 1999 Plans:**

- Continue efforts in maskless lithography, including arrays of miniature e-beam columns, novel imaging materials and pattern transfer processes.
  - Continue network of university efforts in novel patterning. ($ 9.062 Million)
  - Complete column test stand for maskless e-beam writer. ($ 17.000 Million)
- Continue laser plasma x-ray source technology. ($ 6.000 Million)
- Continue x-ray mask writer development. ($ 7.000 Million)
- Develop x-ray masks for the F-22, Apache Longbow and other defense programs. ($ 7.000 Million)
- Continue research in nanotechnology and crystalline control arrays. ($ 3.300 Million)

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(U) **FY 2000 Plans:**

- Develop key tool components, materials and processing to accelerate the availability of emerging lithography technologies beyond 193 nm. Efforts will include maskless (electron beam, ion beam) approaches and the projection technologies, using optical, electron, x-rays and extreme ultraviolet. ($ 26.000 Million)
- Develop support technologies, to include mask technology, resists and metrology. Develop innovative optics designs sand architectures, and new materials and processing beyond the evolutionary trends in the industry. ($ 18.429 Million)

(U) **FY 2001 Plans:**

- Demonstrate maskless wafer writer and characterize performance. ($ 26.000 Million)
- Accelerate technology developments in the lithography exposure sources and supporting (cross-cutting) technologies needed for microelectronics fabrication. Develop reduced risks in key areas of components, materials and processing allowing industry to fabricate prototype tools and new high-performance devices for use in advanced military systems and commercial markets. ($ 19.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jun 99	Demonstrate switched emitter arrays for maskless lithography.
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	System demonstration of maskless charged particle writer.
Aug 02	Demonstrate key components for lithography of 0.07-micron features.
Sep 02	Demonstrate key components for mask writer for sub 0.1-micron features.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-12					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectromechanical Systems (MEMS) MT-12	70.556	76.844	70.098	63.350	70.575	93.100	101.325	98.325	Continuing	Continuing

(U) **Mission Description:**

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences for the monitoring of environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS products into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Among the many accomplishments to date are: a wind-tunnel test of an integrated MEMS sensor and actuator array distributed along the leading edge of a model aircraft wing creating rolling moments of sufficient strength to control aircraft flight, pointing the way to future fighter aircraft with advanced maneuverability unattainable using conventional, large and discrete control surfaces; a demonstration of a MEMS-based accelerometer capable of surviving and operating in the near 100,000 G accelerations generated by firing artillery shells, making possible affordable guidance systems to what are presently unguided munitions and increasing both their effectiveness and life cycle costs; and the establishment of a

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regularly scheduled, shared, MEMS fabrication service for domestic DoD, commercial and academic users. The MEMS program has initiated new efforts in: low power miniaturized communications systems; distributed control aircraft roll and yaw; microscale power; micro airborne sensor/communication systems; data storage; and inertial systems.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Devices and Processes - Accelerated and expanded on MEMS system developments that exploit physics and MEMS systems architecture to project micro-scale actions into macro-scale effects such as micro-optomechanical scanners, switches, displays, adaptive optics and aligners. ($ 19.000 Million)
- System Design and Development - Extended present fabrication processes to cost-effective, large area fabrication approaches. ($ 22.600 Million)
- Support and Access Technologies - Integrated developments in MEMS, robotics and ultra-electronics to design, construct and field multiple, high-performance, mobile, autonomous systems. ($ 8.600 Million)
- Microfluidics - Initiated system-level integration through an evolving testbed strategy, in which the development of new microfluidic components and processes occurred concurrently with the integration of early prototypes with available chip-based molecular analysis components. Leveraged analysis and detection technology from industry, Services and other DoD programs when compatible with microsystems integration. ($ 16.656 Million)
- Continued efforts at Center for Advanced Microstructures Devices (CAMD). ($ 3.700 Million)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	**R-1 ITEM NOMENCLATURE** Advanced Electronics Technologies PE 0603739E, Project MT-12	

(U) **FY 1999 Plans:**

- MEMS Devices and Processes - Demonstrate radio-frequency electromechanical signal processing; MEMS-based mass data storage; massively parallel read/write structures; micro thrusters for satellite attitude, propulsion and control. ($ 10.000 Million)
- MEMS System Design and Development, Phase I - Initiate concept demonstrations for systems in the form of aerodynamic control of model aircraft; low-power wireless integrated microsensors. Demonstrate a MEMS miniaturized fuze/safety and arming device for use in small diameter submarine torpedo counter weapons. ($ 25.500 Million)
- MEMS Systems Design and Development, Phase II - Initiate concept demonstrations for microsensors for structural health, maintenance and monitoring; gas-phase microinstruments; polymer-based MEMS; micro power sources. ($ 22.244 Million)
- CAMD – Continue microdevice manufacturing processes at the Center for Advanced Microstructures and Devices (CAMD). ($ 3.863 Million)
- Microfluidics - Demonstrate a microfluidic sensor system capable of indicating specific DNA hybridization events. Demonstrate detection of pathogens or protein molecules without requiring reporters by using coated beads and DEP/FFF/IS (dioelectrophoresis-field flow fractionation-impedance sensor). Demonstrate prototype microfluidic system to reconstitute a 20-ml volume of lyophilized material in one minute to five- percent reconstitution accuracy using thermocapillary pumping and mixing. ($ 10.000 Million)
- Microfluidics - Demonstrate automated isothermal DNA analyzer: multichannel, microchip device with integrated aerosol collector. Demonstrate portable biodetector prototype with sensitivity for three types each of bacteria, viruses and toxins as well as sensitivity to unknown toxicants by cell or coated beads. ($ 5.237 Million)

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(U) **FY 2000 Plans:**

- MEMS Insertions/Integration - Merge sensing, computing and actuating to realize new systems and strategies. These new approaches will bring new perception and control functions to weapons and battlefield environments. Program is in its third phase, systems demonstrations and insertion, including: microassembled electromechanical signal processing; MEMS aerodynamic pressure sensors on flexible, adhesive tape substrate; modular, monolithically integrated MEMS IMU; and MEMS high-temperature sensor and actuator arrays. ($ 33.906 Million)
- MEMS Devices and Processes - Develop new devices and processes for heterogeneous integration of MEMS, including micro power sources, microprocessor units, micro actuators and communication components. ($ 11.667 Million)
- MEMS System Design and Development - Initiate concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms and chemically powered remote sensors. ($ 9.723 Million)
- MEMS Support and Access Technologies - Initiate demonstrations of MEMS microassembly, packaging and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. ($ 6.538 Million)
- Microfluidics – Demonstrate microanalytical systems "on-a-chip" to sense the battlefield environment. Exploit microscale fluidics integrated with optical and/or electronic detection to monitor chemical, biological, fluid and gaseous substances of importance to the safety of the warfighter and military platforms. Develop and demonstrate new non-optical detection methods that can detect, probe and identify fluids, gases, DNA, cells and protein. ($ 8.264 Million)

(U) **FY 2001 Plans:**

- MEMS Integration/Devices and Processes - Continue development of devices and processes for heterogeneous integration of MEMS, including micro power sources, microprocessor units, micro actuators and communication components. ($ 24.456 Million)
- MEMS Integration/System Design and Development - Perform concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms and chemically powered remote sensors. ($ 16.930 Million)

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- MEMS Integration/Support and Access Technologies - Complete demonstrations of MEMS microassembly, packaging and fabrication at distributed sites for robust sourcing of Integrated MEMS systems. ($ 8.795 Million)
- Microfluidics – Develop new and more efficient specimen collection and concentrator devices to sample the battlefield and military platform environments. Develop self-contained systems for the "just-in-time" synthesis and precise delivery of small amounts of time-critical chemical or biological substances. ($ 13.169 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Mar 99	Demonstrate scanning probe arrays for mass data storage.
Jun 99	Demonstrate multi-frequency, tunable RF and microwave filters, switches and phase shifters.
Jun 99	Demonstrate local micro-encapsulation of inertial instruments.
Sep 99	Demonstrate distributed, multiple, and miniature thrusters for satellite propulsion and attitude control.
Mar 00	Demonstrate microassembled electromechanical signal processing.
Jun 00	Demonstrate miniature aerodynamic pressure sensors on a flexible, adhesive tape.
Jun 00	Demonstrate a modular, monolithically integrated IMU.
Sep 00	Demonstrate MEMS high-temperature sensor and actuator arrays.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technologies PE 0603739E, Project MT-15					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	0.000	0.000	22.568	49.855	45.010	50.000	50.000	50.000	Continuing	Continuing

(U) **Mission Description:**

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at-a-distance, a paradigm that addresses many of the present and future needs of the DoD. These 'wrist watch-size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectronics, microelectromechanical systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies and thereby create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave

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technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Not Applicable.

(U) **FY 1999 Plans:**

- Not Applicable.

(U) **FY 2000 Plans:**

- 3-D Imaging – Initiate program to develop new high speed imaging device technology to rapidly acquire a high resolution 3-D image of a tactical target at ranges of 7-10 kilometers increasing identification range of tactical targets, especially from fast moving platforms. Develop near infrared materials with point defect density less than 1000/sq cm. Demonstrate 4x4 array of detectors with gain of 30 at 1GHz. Complete investigation of novel high gain detector concept. ($ 7.357 Million)

- Steered Agile Laser Beams – Initiate program to develop compact, light weight, man-portable, electronically steered lasers to replace large, heavy gimbal mounted lasers in lasercom links and smart weapon target designators. Develop small, light weight laser beam scanner system technologies for replacement of gimbaled mirror systems. Initiate system design and component specifications; select system design. ($ 6.867 Million)

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- RF Lightwave Integrated Circuits (R-FLICS) – Initiate program to demonstrate, with heterogeneous integration, lightwave and RF technologies to route, control and process analog RF Signals in the 0.5-50 GHz range. Develop RF-Photonic modules that enable links with better than zero net RF loss from input to output. Develop and demonstrate optically integrated modules capable of performing complex RF functions such as signal channelization or single chip generation of multiple RF signals. ($ 8.344 Million)

(U) **FY 2001 Plans:**

- 3-D Imaging – Complete design of high speed electronics for sub-nanosecond detection. Integrate high speed electronics with 5x5 detector array and integrate into brass board imaging system. Demonstrate laboratory imaging with 5x5 array. Select detector design for 128x128 3-D imaging array. ($ 16.500 Million)

- Steered Agile Laser Beams – Develop electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units, which are able to transmit images and geo-location data of targets, and for use in target designators for small unit operations in high threat environments. Develop beam steering and detection systems. ($ 17.500 Million)

- R-FLICS – Focus program on identified key applications for integrated RF-Photonic modules and produce initial prototypes and demonstrate methods for evaluation of their performance. Initiate parallel efforts to develop components for efficient RF links exhibiting better than zero net loss and to demonstrate the advantages of integrated optical-RF modules for RF systems. Down select among technology options and develop prototype module for demonstration. ($ 15.855 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
3-D Imaging:	
3Q00	Develop low defect density near infrared materials suitable for high speed imaging.
4Q00	Demonstrate detector test arrays with gain/bandwidth product capable of sub-nanosecond detection at long range.
2Q01	Integrate novel, high gain/bandwidth detector array with low noise electronics.
Steered Agile Laser Beams:	
2Q00	Select system configuration which best meets insertion target performance goals.
3Q00	Derive component specifications.
R-FLICS:	
2Q01	Demonstrate High Performance R-FLIC Components to 50 GHz bandwidth.
4Q01	Demonstrate integrated R-FLIC functions such as channelizer with 10 GHz selectivity over 0-50 GHz bandwidth.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Electric Vehicles PE 0603747E, R-1 #43					
COST (*In Millions*)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	15.000	9.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Electric Vehicles EV-01	15.000	9.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) Electric and hybrid electric drivetrains provide compelling advantages for future tactical and combat vehicles. Of particular importance is a 50-percent reduction in fuel consumption due to higher efficiency, improved acceleration and maneuverability due to immediate torque to the wheels or tracks, and dramatically reduced thermal and acoustic signatures when operating from on-board energy storage. Affordability is addressed through reduced logistics requirements and the dual use applications of these technologies.

(U) The DARPA Electric and Hybrid Vehicle Technology program is pursuing research, development, and demonstrations of technologies for electric and hybrid vehicles that address military missions, modernization, and cost mitigation. Established by Congress in FY 1993, the program has pursued technology development and prototype demonstrations that are essential for future military systems, enhancing national energy security, and facilitating compliance by the Armed Services with federal clean air legislation. DARPA uses a unique decentralized management approach working directly with seven regional consortia. These diverse consortia provide a minimum of 50% of the funding and cooperatively function to overcome the challenges of developing electric and hybrid vehicle technologies. Consortium participants include military laboratories and bases, state and local governments, large and small defense contractors, well-established and startup manufacturers of vehicles and components, electric and gas utilities, public interest groups, and universities. Military requirements and infrastructure are implemented within this program at minimal federal investment, leveraging significant private funds.

(U) Technology development is focused on: High-specific power engine/generator sets, including multi-fuel capable, high efficiency, and low emissions turbines, diesels, and rotary engines; Power control devices, including high-performance power semiconductors, control algorithms, and circuit integration and packaging; Energy storage devices, including advanced batteries, rapid battery recharging, flywheels, and capacitors; Electromechanical conversion, including alternating current, direct current, and linear motors; and lightweight high-strength materials, including space-frames and composites. These dual-use electric drivetrain technologies are being demonstrated in both commercial and military chassis. The

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technologies are directly relevant and are coordinated with the DARPA Combat Hybrid Power Systems (CHPS) and Reconnaissance Surveillance and Targeting Vehicle programs (budgeted under PE 0603764E, Project LNW-01).

(U) The program is transitioning to the Department of Transportation in FY 1999. The Research and Special Programs Administration of DOT has budgeted to continue the program in FY 2000.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Completed development of the hybrid electric Bradley Fighting Vehicle and completed development and field testing of hybrid electric High Mobility Multi-Purpose Wheeled Vehicles (HMMWVs) and electric M-113. ($ 2.800 Million)
- Developed and tested additional medium and heavy-duty hybrid electric vehicles. ($ 2.000 Million)
- Developed and tested turboalternator and other auxiliary power units for medium and heavy hybrid electric vehicles. ($ 1.000 Million)
- Further integrated and tested flywheel energy storage units with containment. ($ 2.100 Million)
- Developed and tested improved and reliable batteries, battery chargers, and battery management systems. ($ 4.000 Million)
- Developed and tested improved drivetrain and other components of hybrid electric vehicles. ($ 3.100 Million)

(U) **FY 1999 Plans:**

- Complete field testing of the hybrid electric Bradley Fighting Vehicle. ($ 0.700 Million)
- Perform lifetime safety tests on flywheels, improve flywheel bearings, and install flywheels in vehicles. ($ 1.400 Million)

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- Apply high energy and high power battery systems to vehicles. ($ 2.500 Million)
- Integrate hybrid electric drivetrain and controls into medium and heavy-duty vehicles. ($ 4.400 Million)

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	14.522	0.000	0.000	0.000
Current Budget	15.000	9.000	0.000	0.000

(U) **Change Summary Explanation:**

FY 1998 Increase reflects minor program repricing.
FY 1999 Funds added in the Appropriations Act to ensure program continuity pending DOT funding.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
May 98	Completed preliminary designs of turboalternators for hybrid electric vehicles.
Dec 98	Completed demonstration of hybrid electric propulsion of second High Mobility Multi-purpose Wheeled Vehicle (HMMWV).
Dec 98	Completed testing of rapid charging units.
Apr 99	Complete field test of electric M-113.
Apr 99	Complete field test of two hybrid electric HMMWVs.
Jun 99	Complete demonstration of hybrid electric propulsion of Bradley Fighting Vehicle.
Nov 99	Complete field test of hybrid electric Bradley Fighting Vehicle.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	147.525	177.492	222.888	213.380	210.483	199.480	219.046	218.671	Continuing	Continuing
Command Control Information Systems CCC-01	65.219	86.596	109.933	109.834	94.734	93.734	104.034	104.834	Continuing	Continuing
Information Integration Systems CCC-02	82.306	90.896	112.955	103.546	115.749	105.746	115.012	113.837	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. The primary program in this project is the Joint Forces Air Component Command System (JFACC), which will revolutionize command and control of joint and coalition air forces through the incremental development, integration, evaluation, demonstration, and transition of technology and systems. Other programs addressed in this project include: the Information Assurance program, the Advanced ISR Management program, the Agent-Based Systems program, Project Genoa, and the Active Templates program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real time basis. Programs addressed in this project include the Dynamic Multi-User Information Fusion (DMIF) program terminating in FY 1998, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future program, and Course of Action Analysis program.

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(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	150.010	200.100	187.369	206.234
Current Budget	147.525	177.492	222.888	213.380

(U) **Change Summary Explanation:**

FY 1998	Decrease reflects rephasing of the BADD ACTD and SBIR reprogramming adjustments.
FY 1999	Decrease reflects congressional reductions to the Joint Forces Air Component Command System (JFACC) and Dynamic Database (DDB) programs; termination of the Dynamic-Multi-User Information Fusion (DMIF) program.
FY 2000-01	Increases reflect transition of Project Genoa from PE 0602702E, Tactical Technology, Project TT-03; increases to the Airborne Communications Node (ACN) program for completion of payload integration and bench tests; and the Information Assurance program.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Command Control Information Systems CCC-01	65.219	86.596	109.933	109.834	94.734	93.734	104.034	104.834	Continuing	Continuing

(U) **Mission Description:**

(U) Recent military operations, e.g., Desert Storm and Haiti, demonstrated that current theater command, control, communications, intelligence/information systems, planning and rehearsal systems; and non-lethal weapon's capabilities lack the ability to support effective operations in diverse new arenas and scenarios ranging from desert heavy battle actions to urban areas with large civilian populations. Current capabilities do not provide real-time situational awareness, decentralized battle planning, rehearsal and execution capability, flexible interfaces or critical interoperable wide-area communications. The goals of the programs in this project are to build on an innovative architecture and infrastructure to enhance information processing, dissemination and presentation capabilities for the Commander by inclusion of information pertaining to enemy and friendly forces, providing a joint situational awareness picture and improving planning, decision-making and execution support capability and providing multimedia information interfaces and software to "on-the-move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through information systems.

(U) The Joint Forces Air Component Commander (JFACC) Project seeks to revolutionize command and control (C2) of joint and coalition air forces through the incremental development, integration, evaluation, demonstration and transition to the Warfighter of advanced information technologies and software components which will enable new operational C2 concepts and capabilities that will significantly improve the responsiveness, efficiency, effectiveness, and flexibility of air operations. Key aspects of the program are: continuous near-real-time planning, execution, and assessment with all tasks tied to a central strategy and embodied in a common plan representation; collaboration among distributed elements to achieve a high degree of integration through the echelons and across operations, intelligence and logistics; and stable and agile control of theater-wide operations. Software modules will be developed with advanced capabilities for campaign and detailed planning, execution management, resource and adversary analysis, process control, and information/knowledge management. Key technologies include automated and mixed-initiative reasoning, intelligent resource allocation and scheduling, dynamic workflow management, system dynamics modeling and control, information mediation and fusion, knowledge representation and acquisition, and decision-centered information presentation. These technologies will be applied to needs that include: continuous processes that quickly anticipate and react to changes in guidance, threat situation, resource availability and synchronization; full integration of intelligence, logistics and operational activities to support integrated and prioritized operational tasks; empowerment of cross functional teams to quickly respond to battlespace changes; and continuous decision-space awareness to support rapid

option assessment and decisions at multiple echelons. JFACC technologies, that support operational level decision making and information processing, will be interoperable with related DARPA programs (e.g., Advanced Logistics Project (ALP), Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM), and Agile Information Control Environment (AICE)). Program execution features a multi-phased, develop-experiment-transition approach, including close coordination with the Air Force and Navy Battlelabs and other service C2 organizations.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. Information Assurance (IA) technologies will be integrated into future versions of the Defense Information Infrastructure (DII) to provide a robust architecture across a wide range of DoD information systems. The development and fielding of secure information systems will be a continuing process of development and upgrading of existing systems and capabilities. The program is developing and refining information security technology into DII architectures and testbeds. As part of the program, the IA project is beginning to build a science and engineering discipline base for information assurance. One hypothesis to be tested is whether it is possible to create trustworthy systems from innovative integration of relatively untrustworthy mechanisms. The resulting security framework will reduce information vulnerability, allow increased interoperability and functionality, and provide the operational commander greater assurance that he will have the information he needs when he needs it. The initial investment provides near term applications to provide a modest level of protection, and a mechanism to test advanced secure information development in an end-to-end environment.

(U) A new generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) project will expand on efforts begun under the JFACC program and provide the technical foundation for ISR support to Joint Vision 2010 and beyond through the development of Information Management, Collection Strategy Development, and Multi-asset Synchronization capabilities to dynamically optimize/synchronize, schedule, and task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM project will optimize ISR support to precision engagement and dominant maneuver by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM's Information Management effort will insure near-real-time (NRT) information support to commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and

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shared decision making. AIM's Collection Strategy Development effort will interoperate with future automated operational plan representations to continuously interpret ISR requirements contained in the plan and decompose these requirements into discrete sensor, information retrieval, and exploitation tasks. AIM's Multi-Asset Synchronization effort will simultaneously plan and integrate platform routes and schedules that maximize the total information value from the ISR confederation in support of the operational plan. The AIM project will develop or advance technologies in the following areas: workflow management, multi-node collaboration, social computation, automated reasoning, mathematical programming, and cognitive representations. Resulting AIM capabilities will transition to DoD automated planning and C4ISR migration systems as appropriate.

(U) The Control of Agent-Based Systems Program will develop control strategies that enable intelligent software assistants for warfighters allowing them to delegate tasks such as information gathering, logistics supply, and operations planning that can be automated, but currently overload military personnel. Unlike other software, agents reduce the user's workload by operating autonomously and using available information to make intelligent decisions on behalf of the user. Agents are cost-effective; adaptive to new users, tasks, and computing environments; and collaborate with other agents on the network to solve problems. Agents also support a new lightweight approach for connecting dissimilar applications that don't speak the same language, but could be dramatically more powerful by sharing data and algorithms. Commercial industry is rapidly adopting intelligent agent technology because it potentially lowers software development costs and automates user tasks. However, being autonomous, agents can misinterpret user requests, go out of control, consume system resources, destroy user confidence, and eliminate any advantage to developers. Systems of agents produced by different developers can interact in complex ways. The Control of Agent-Based Systems Program will complement commercial investment by developing control strategies to ensure heterogeneous agent systems work correctly and predictably in the evolving Defense Information Infrastructure.

(U) Project Genoa is developing tools and a prototype infrastructure for collaborative crisis understanding and management for the national security community ranging from the National Command Authority to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. Genoa will use technologies from

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other DARPA projects such as Information Assurance as well as commercial technologies. The current clients for components of the prototype system are Commander in Chief Pacific (CINCPAC) and Director Defense Intelligence Agency (DIA). This project was initiated and budgeted in PE 0602702E, Tactical Technology, Project TT-03, but as it has evolved, it transitioned to CCC-01 in FY 1999.

(U) The Active Templates (AcT) program will produce a robust, lightweight software technology for aiding in the automation of detailed planning and execution for military operations using a plan spreadsheet metaphor. Active Templates are distributed data structures whose variables will be linked to live data feeds or problem-solving methods. Active Templates will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, scalable and widely adopted. As a result, the technology to be fielded will provide faster plan generation (6X), improved plan quality (8X more options considered), 60% reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Demonstrated and evaluated at the Air Force C2 Battlelab the basic JFACC Project technology/application building blocks and system architecture. Also, demonstrated initial interoperability of selected JFACC component prototypes with several other DARPA projects. ($ 30.237 Million)

- Developed concept of operations for Integrated Battlespace Management Program. ($ 2.954 Million)

- Demonstrated Information Assurance (IA) automated capabilities to limit system access, and prevent system attacks by layering privacy security service over enclave-to-enclave protection and filtering out active code that is dangerous to enclave systems. Demonstrated gross responses for disabling attacks by shutting down outside connection and system-wide recovery. Demonstrated mechanism interoperability with negotiation protocols and good system administration tools to manage security mechanisms in DII Leading Edge Services (LES). Integrated a basic Public Key Infrastructure certificate management system to support basic security services. ($ 19.657 Million)

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- Awarded AIM development contracts for initial Measures of Military Utility, trade studies and trade-off analysis, and designed tools for information management, strategy development, and multi-asset synchronization. Conducted a Concept Validation demonstration of emerging multi-asset synchronization algorithms. Conducted AIM Technology Symposium to demonstrate high-risk / high-payoff technology development areas for collection strategy optimization, predictive analysis for battlefield awareness, automated information needs development, and dynamic replanning for multi-asset synchronization. Transitioned asset allocation algorithms to the Discoverer II program office for use in architecture analysis and trade studies. ($ 7.638 Million)

- Completed the transition and provide one year of maintenance support to the operational Advanced Joint Planning ACTD to USACOM. Conducted a formal assessment of the ACTD's functionality. Completed transition of selected components. ($ 1.813 Million)

- Developed testbed environment to support the simulation, testing, and evaluation of large-scale agent systems, including agent control strategies and agent architecture. ($ 2.920 Million)

(U) **FY 1999 Plans:**

- Incorporate preliminary JFACC project results and lessons learned into system constructive models of both the JFACC proper, as well as subordinate wings and squadrons. Perform stability experiments to understand the end-to-end system stability issues across a spectrum of JFACC planning cycle times. Begin development of JFACC planning, assessment and control system modules. Begin development of interoperability technologies required to support operation of JFACC system components across heterogeneous operating environments. Perform cross program integration experiments with other advanced planning programs, specifically, logistics, intelligence, and operations with focus on semantic interoperability issues. ($ 27.750 Million)

- Demonstrate automated capabilities to limit system access, protect data, manage replication and recovery, provide advanced detection and response to intrusions, anti-flooding techniques, and reconstitute/ reconfigure information services to reflect dynamic operational priorities. Demonstrate capability to do integrated monitoring of network service data, detected intrusion status and configuration/reconfiguration; manage allocation of components and resources dynamically to reconstitute critical functions that have been degraded. ($ 24.490 Million)

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- Develop AIM tools for information management, strategy development, and multi-asset synchronization. Conduct data collections at Special Project '99 to support technology development. Evaluation of ISR, logistics, and operations planning in an integrated experimental demonstration with the JFACC and ALP projects. ($ 9.550 Million)

- Develop and test cooperative, federated, and market-based control strategies for Agent-Based Systems to assist information gathering and enhance military planning capabilities. ($ 13.644 Million)

- Project GENOA will begin user evaluation of selected components to establish performance metrics relevant to crisis situations. These experiments will include initial knowledge discovery, structured argumentation, and argument presentation tools. Components of the prototype system will be deployed to CINCPAC, DIA, and the DARPA test site for these user experiments and evaluations. Develop parameterized problem-solving algorithms, a simple representation languages, and a symbolic spreadsheet interface for building, tailoring, and using templates for real-time distributed planning and execution. ($ 11.162 Million)

(U) **FY 2000 Plans:**

- Continue the development of JFACC system modules. Select the most promising components for software implementation. Using those components, conduct JFACC planning experiments to quantify planning time and staff reductions that can be achieved using JFACC technology. Experimentally evaluate JFACC prototype modules at the Service Battlelabs to assess individual module military utility and to explore Concept of Operations. Complete the development of strategy-to-task planning capabilities and conduct operational experiments to assess the operational utility of this capability. Begin development of inter-module process controller. Continue cross-program integration experiments. ($ 34.005 Million)

- Demonstrate automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules. Demonstrate real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Couple advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration. Dynamically and automatically manage allocation of components and resources to reconstitute critical functions that have been degraded. Demonstrate security policy interoperability between enclaves. Explore Knowledge Base approach to adaptive systems management. Improve assurance measurement

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and risk analysis by establishing value functions for user data. Enhance object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC). ($ 30.654 Million)

- Demonstrate dynamic replanning capabilities within an integrated collection management demonstration. Develop collection, exploitation, and dissemination synchronization techniques to link all phases of ISR management in support of the warfighter. Transition initial automated collection strategy tools to the Integrated Collection Management efforts in the Defense Intelligence Agency and the Joint Staff. ($ 9.799 Million)

- Develop an enhanced agent communication language, an agent programming methodology and component libraries. Identify standard, protective agent services. Integrate compatible models of agent behavior. Demonstrate and stress-test in a military exercise 5-fold speed-up to plan and execute a time-critical operation. For commanders critical information items, demonstrate automated tracking and notification with 95% reliability with less than 5% false alarm rate. ($ 15.877 Million)

- In Project Genoa under knowledge discovery develop and implement information extraction from text and extensive use of intelligent agents, in structured argumentation refine crisis models and develop collaborative option generation, continue work on meeting transcription and develop ability to navigate and play back corporate memory. Implement products from Information Assurance project so that a multi-intranet system may operate at mixed security levels. Continue evaluation at CINCPAC test site. ($ 11.759 Million)

- Develop and encode templates of standard operating procedure which integrates causal model capability to show how constraints, event triggering, inference, and uncertain reasoning can be utilized for fast crisis planning and execution. ($ 7.839 Million)

(U) **FY 2001 Plans:**

- Continue the development of JFACC system modules. Integrate JFACC modules into an end-to-end working prototype including process control. Conduct high-fidelity stability experiments to complete dynamic characterization of the JFACC process. Conduct robustness experiments by testing the JFACC prototype across a broad range of operational scenarios. Establish multi-echelon control gains required to achieve global stability while minimizing planning and execution time. Continue operational experiments in conjunction with Service battlelabs for military utility assessment and concept of operations development. Begin experiment of system scalability issues. ($ 35.034 Million)

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- Develop automated cyber immune response capability utilizing advanced attack detection indications and warning systems integrated with adaptive system monitoring and control. Apply artificial diversity to the adaptive systems. Develop security enabling technologies for autonomous software agents that allow agents to function safely across enclaves. Enhance object assurance granularity by augmenting DCOM and JAVA Remote Method Invocation (RMI). Develop automatic security policy discovery and negotiation capability among enclaves. Advance assurance measurement capabilities by developing IW attack countermeasure cost/benefit tools. Develop information warfare indications and warning (I&W) tools, utilizing data fusion techniques, to provide Defense Information Infrastructure (DII) wide I&W capability. ($ 35.000 Million)

- Conduct operational evaluation of AIM automated collection strategy development and multi-asset synchronization technologies at Special Project 2001. Incorporate predictive Indications and Warnings technologies into the automated collection strategy development tools. Transition multi-asset synchronization and automated collection strategy development tools to the Discoverer II program office and classified ISR management systems. ($ 10.000 Million)

- Scale-up reliable agent systems. Develop and test methods for understanding large-system autonomous behavior. Demonstrate proof-of-concept prototype for self-configuring software applications comprised of network services and quantify utility for highly complex, dynamic command and control problems. ($ 12.800 Million)

- Project Genoa: Implement products from Information Assurance project to permit operations in a multi-level security environment. Incorporate changes resulting from client evaluation in real world environment. ($ 7.000 Million)

- Integration and demonstration of multiple template merging by users to update information, add dependencies, and attach problem-solvers ($ 10.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Jun 99	Demonstrate computer network resource protection for pathogenic agent systems.
Sep 99	Integrate a basic Public Key Infrastructure certificate management system to support basic security services. Demonstrate basic replication techniques and anti-flooding techniques (port filtering).
Sep 99	Demonstrate integrated ISR and operations planning in an integration experiment with JFACC, ALP and AIM at the Technology Integration Center.
Sep 99	Release initial Active Template toolbox with symbolic spreadsheet interface and parameterized problem-solvers.
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Jun 00	Demonstrate AIM automated collection strategy development and continuous multi-asset planning within an integrated collection management demonstration.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.
Jul 00	Demonstrate Knowledge Base approach to systems management.
Jul 00	Demonstrate user data value functions.
Jul 00	Demonstrate rapid knowledge discovery and structured argumentation in crisis management.
Jul 00	Demonstrate and experimentally assess individual JFACC module/component prototypes for campaign and detailed planning, execution management, resource and adversary analysis, process control, and information/knowledge management. Evaluate JFACC system capabilities for cross-functional strategy-to-task linkage, and distributed and dynamic process management.
Sep 00	Demonstrate augmented CORBASEC.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.
Sep 00	Demonstrate semi-automated templates handling incomplete data amidst 100 execution changes in a military exercise.
Dec 00	Demonstrate tools for analysis of IW attack costs.
Dec 00	Demonstrate system recognition of malicious code.
Mar 01	Demonstrate dynamic policy adjustment.
Jun 01	Demonstrate agents that dynamically create software interfaces; define scalability limitations.
Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.

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Jul 01	Demonstrate operational prototype crisis management system functionality.
Jul 01	Demonstrate and experimentally assess integrated JFACC module/component implementations for campaign and detailed planning, execution management, resource and adversary analysis, process control, and information/knowledge management. Evaluate JFACC system level timing and stablity within the context of continuous and interleaved planning, execution, and assessment.
Sep 01	Demonstrate prototype adaptive security system and prototype DII I&W system.
Sep 01	Conduct operational evaluation of AIM's automated collection strategy development and dynamic multi-asset synchronization tools. Initial demonstration of AIM's predictive indications and warnings technologies.
Sep 01	Demonstrate augmented DCOM and JAVA RMI.
Sep 01	Demonstrate that users can tailor their own templates, update information, add dependencies, and attach problem-solvers. Show that active template technology is scalable in that 50 templates have been built. Show that planning speed doubles and plan quality improves.
Jun 02	Demonstrate agent-based software technology for creating "super-applications" at run time.
Jul 02	Complete Project Genoa by turning over transition to customers.
Aug 02	Operational evaluation of integrated AIM capabilities for dynamic and proactive information needs generation, optimized collection strategy development, multi-asset synchronization for execution of the selected collection strategy, and continuous collaboration between operations and ISR.
Sep 02	Show six-fold increase in execution replanning using Active Templates attached to live data feeds from battlefield sensors.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Integration Systems CCC-02	82.306	90.896	112.955	103.546	115.749	105.746	115.012	113.837	Continuing	Continuing

(U) **Mission Description:**

(U) The goals of the Information Integration Systems project are to take diverse inputs, including those planned as outputs, from the PE 0603762E Sensors and Exploitation Systems project (SGT-04), and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Multi-User Information Fusion (DMIF) program, the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future (CPoF) program, and Course of Action Analysis program.

(U) The Dynamic Multi-User Information Fusion (DMIF) program was an advanced technology development program for the defense and intelligence communities, including next-generation automated capabilities to support the operational service fusion systems: All Source Analysis System (ASAS), Theater Battle Management Core System (TBMCS), and Global Command and Control System (GCCS). The DMIF-created situation picture would reduce information overload and overcome barriers to interoperability among sensor exploitation sites, intel processing sites, and operators' decision nodes. The DMIF program was terminated in December 1998.

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to a diverse user community. More specifically, the DDB program will design, build, and demonstrate a system that (1) provides ready access to all battlespace sensor observations collected over time, (2) uses the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and (3) shares and synchronizes local situation changes across the distributed battlespace. Dynamic Database contents will be maintained and shared through a Dynamic Situation Model (DSM) that integrates geo-registered sensor history data with terrain, environmental, and force information to yield a logically consistent, multi-level view of the battlespace. Single and multi-sensor data fusion approaches will be developed that efficiently update the DSM by filtering tactically significant changes from the Dynamic Database sensor history. This objective includes the development of theory and techniques for incorporating mission and situation context into low-level processing algorithms, and advanced phenomenology models for translating expected conditions and behaviors into

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multi-sensor observables. Significant situation changes will be shared throughout the battlespace within a scaleable "DDB enterprise" of distributed DSM nodes, computing applications, processors, and information repositories. DDB enterprise technologies will be developed to monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes across DSM nodes, and support queries and searches of distributed databases.

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD) is to deliver, install and evaluate an operational prototype system that delivers to warfighters a consistent operational picture of the joint/coalition battlefield, allows commanders to design/tailor their own information environment, and provides access to key transmission mechanisms and worldwide data repositories. The description of the battlespace provided to the warfighters under this ACTD will be tailored to their mission needs by intelligent selection of information to be broadcast, intelligent processing of user requests (pull) and filtering at the warfighter workstation so that needed information is available. BADD will be evaluated through participation in a series of collaborative assessments, demonstrations, and a military utility assessment. BADD is also operating under a Memorandum of Agreement with the Global Broadcast Service Program Office to provide advanced information management capabilities and new applications for this system as part of the overall transition plan of BADD developments to operations after test and evaluation in the ACTD. Selected applications and dissemination services will be transitioned to the Defense Information Systems Agency (DISA) for incorporation into the Defense Information Infrastructure Common Operating Environment (DII/COE).

(U) To avoid confusion, the Phase III (Technology Improvement) phase of BADD will henceforth be renamed Agile Information Control Environment (AICE). AICE will focus on developing and demonstrating breakthrough information management technologies that provide 10 times improvement in the efficient and timely delivery of information; that extend current information management services to support time critical and real-time information flows (e.g., sensor to shooter); and that optimize information flows based upon maximizing the value of information delivered vs. today's practice of maximizing the volume of data delivered. To successfully demonstrate the operational payoff of these capabilities, AICE will develop a prototype MetaNet that provides end-to-end quality of service across multiple tactical and commercial-based networks. AICE will also develop an Adaptive Information Controller that optimally allocates the resources of shared information infrastructure (networks, servers, guards, etc.) based upon overall operational concerns. AICE will develop Information Policy Management Tools that enable a commander of a large military enterprise to create, establish and maintain an enterprise wide specification of information flow priorities. AICE will also develop a unifying theoretical basis for characterizing and measuring the performance of Adaptive Information Control components. Performance Analysis and Integration experiments will be conducted to integrate and measure the performance of AICE components via a series of experiments that utilize the theoretical basis developed.

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(U) The Airborne Communications Node (ACN) program will provide a multifunction payload deployable on an airborne platform that demonstrates for the first time that a single communications node can interconnect, much beyond current radio range (beyond line of sight and horizon), more than 70 different channels and 17 waveforms. This capability will provide tactical units with direct access to over-the-horizon communications capability and continuous broad area communications coverage over the battlefield, with cross-system connectivity amongst on-the-move warfighters – to include Joint and Coalition forces - significantly improving rapid force projection, synchronization and synergy. To connect isolated and rapidly maneuvering forces via high data rate communications, provide reach-back connectivity to CONUS from forward elements, allow gateway connectivity among dissimilar radios and support secure channel-based dynamic configuration control requires the development of a system capable of providing reliable service in a severe EMI and jamming environment. This is achieved through the development of a highly flexible, software reprogrammable radio communication system that incorporates a complex cosite mitigation approach. A prototype payload is being developed to be supportable on a Global Hawk High Altitude Endurance unmanned airborne vehicle, but the system is designed to be flexible and scalable to any airborne platform, including tactical UAVs and manned platforms, for rapid deployment, thus enhancing the existing legacy communications capability, providing new commercially-derived services (i.e., cellular) and enabling support for the small unit operations and mobile command centers of the future. The Airborne Communications Node program will integrate Warfighter Internet functionality to provide Internet-like communication services across multiple airborne nodes. The program will conclude with field demonstrations in FY 2002.

(U) The objective of the Command Post of the Future (CPoF) program is to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems required to do so. The approach is to provide a very intuitive, well integrated, decision-centered, information environment in which the commander and a few staff members can quickly understand the changing battlefield situation, select the best course of action (COA), communicate that COA to the implementing units, and monitor the execution. The key technologies to be developed are: (1) an integrated visualization environment where the commander and his staff can view immediately understandable presentations of the changing battlefield situation, presentations which are tailored to the situation and the command decisions of interest; (2) a powerful and comprehensive human-computer interaction capability (through speech and gesture understanding, language understanding, dialog management, and visual collaboration) so that the commander and his staff can successfully understand and explore the information environment, without requiring dozens of staff members to operate and integrate multiple information systems; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of knowledge bases, intelligent agents, plan sentinels, information processing assistants which would automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command.

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(U) The Course of Action Analysis (COAA) program is focused on advanced technology development in the area of Course of Action Analysis. The program is developing a set of tools for performing COAA that can be demonstrated to determine the ability of these tools to support large-scale combat events.

(U) Real-Time Infrastructure Capabilities Assessment (RICA) will develop new technology for improving the military's capability to perform real-time effects-based targeting and re-targeting of infrastructure systems. The current technology supports the capability to perform sophisticated analyses of an enemy's infrastructure and select targets based on causal models of the effects of the targeted components on overall system performance. The current limitation of this technology is that the development, maintenance, and operation of these analytic models is manpower intensive and time consuming – preventing the use of effects-based targeting in real-time course of action generation. This project effort will evaluate the current processes used to accomplish effects-based targeting and develop new sensor exploitation and information exploitation technologies to enable the real-time generation of courses of actions based on the high-precision target analyses.

(U) The purpose of the SkyLink program is to provide mobile tactical users with multimedia C^2I (voice, data and video) using broadband commercial satellites. SkyLink will help enable the Next Generation Command and Control vision by providing the data bandwidths that support real-time video conferencing, distributed collaboration, image transfer, multi-media database access and interactive visualization to distributed, mobile operations personnel as well as to isolated mobile forces. It is projected that burst data rates on the order of hundreds of megabits per second to mounted forces and tens of megabits per second to dismounted forces can be achieved.

(U) The Asymmetric Threat component will develop information technology to provide improved awareness of asymmetric threats. New techniques will be developed: to automatically monitor and extract facts about people, places and activities from speech and textual data sources; to automatically discover network links and relationships from a large collection of facts about a terrorist network; to model and reason about a terrorist's groups capabilities and intentions; to derive a set of potential sites and activities to watch for based on a terrorist's group's capabilities and intentions; and to manage the exploitation and fusion of heterogeneous sensors to automatically monitor for those activities.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- DMIF: Continued development of the DMIF system to implement strategically controlled fusion, that is, real-time context-sensitive tasking of multiple fusion engines. This tasking adapts to the characteristics of available or incoming information, the performance of the available information processing applications (such as ASAS, CIS, or GCCS), and the specific tactical situation (as represented by the commander's critical intelligence requirements or via automated planning systems). By selecting fusion engines and tuning their parameters based on the real-time context, strategic control of multiple fusion engines ensures that users get peak performance over a much broader range of conditions than any single fusion engine could provide. Systems include fusion engines from the Army, Air Force, Navy, national agencies, and R&D systems. Demonstrated functionality at integrated operations/intelligence demonstrations with the JFACC program, the DARPA-DISA Joint Program Office, and transitioned components into ASAS. ($ 11.689 Million)

- Dynamic Database (DDB) Program: Completed the Phase I DDB architecture design. Installed the DDB System Integration Laboratory (SIL) to facilitate the exchange and evaluation of ideas and approaches, support distributed experimentation requirements, incubate and integrate evolving DDB technologies, and conduct system and technology proof-of-concept demonstrations. Laid the foundation for future DDB development by integrating existing "backbone" products (such as algorithms, phenomenology models, software, and databases) into the DDB SIL. In conjunction with DMIF, produced an initial object schema for the Dynamic Situation Model. Initiated single and multi-sensor fusion algorithms research and demonstrate a prototype update service for the sensor history layer of the Dynamic Database. Produced initial geo-registration and mosaicing tools for SAR, MTI, IR, and SIGINT sensor and incorporate tools in the Dynamic Database computation services. Developed a limited spatio-temporal database query capability. Produced an application programming interface specification for the Dynamic Database management system. Incorporated the initial Dynamic Situation Model object schema into the Dynamic Database and demonstrate the ability to ingest and process raw sensor data. Collected SAR, MTI, IR, EO, and SIGINT sensor data in preparation for FY 1999 activities. ($ 14.986 Million)

- BADD ACTD: Released the initial version of Phase II software (Release 1) increasing the level of automation previously provided to users and extending information management and dissemination support to the level of individual battalions/ships. BADD stood up six CONUS pilot service sites to include the Army, Air Force, Navy, ACOM and JBC. Completed collaborative assessments at two of the six

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pilot service sites that were evaluated by ACOM, the operational sponsor. Stood up the first digital tactical video server and demonstrated real-time population of that server, as well as automated meta-data generation for a number of tactical video surveillance platforms. ($ 43.820 Million)

- Airborne Communications Node (ACN): Selected multiple teams and initiated competitive ACN system design technology integration efforts. Initiated core technology integration from Warfighter's Internet and GLOMO programs and conducted initial technology investigations of very high bandwidth air-to-air and air-to-ground communications. The Warfighter's Internet Program integration with the ACN Program began. ($ 8.318 Million)

- Command Post of the Future: The program focused on defining operational concepts for the new system and developing a concept demonstration to show operational users for evaluation and feedback. A group of operational advisors was formed from service representatives at the Army Battle Command Battle Lab – Ft. Leavenworth, the Mounted Maneuver Battle Lab at Ft. Knox, and the Marine Corp Warfighting Lab at Quantico. User studies were conducted by visiting operational military units to construct initial concepts of operation for CPOF, focusing on the Joint Land Forces Component Commander (JFLCC) as the target user. A concept demonstration was developed by integrating emerging technology in visualization, speech understanding, human-computer interaction, and decision aids to create an initial demonstration of envisioned CPOF capabilities. ($ 3.493 Million)

(U) **FY 1999 Plans:**

- Complete a Phase II DDB architecture design. Develop and validate single-sensor terrain and entity phenomenology models. Develop prototype multi-sensor target phenomenology models. Elicit and incorporate situation context into single and multi-sensor anomaly detection algorithms. Demonstrate a prototype update service for the entity layer of the Dynamic Database. Integrate technology products in the DDB SIL and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns and mosaics the data within a common 2-D spatio-temporal reference frame, identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data. ($ 23.595 Million)

- BADD ACTD: BADD will provide new information management capabilities to include creation of a 3-D graphical depiction of a consistent operational picture by near-real-time integration of all relevant databases, demonstrate variable information management, control information flows' content and resource allocation based on operational priorities, across constrained servers/networks,

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demonstrate near real time deliver of digital video streams/video products to tactical users. Video data will be filterable based on meta-data tagging (i.e. geographic area, video content) and will be merged into the Battlefield Awareness display. Complete military utility assessment at Roving Sands. Begin the 2-year ACTD sustainment phase. Operate Pilot Services and begin transition of initial CONUS and OCONUS Pilot Services to DISA. Complete the transition of integrated tactical video services to NIMA (video archiving tools) and to DISA/GCCS (video viewers). ($ 14.459 Million)

- AICE: Begin AICE technology development in MetaNet, Adaptive Information Control (AIC) and Information Policy Management (IPM) areas. Begin theoretical framework and metrics development. Begin developing prototype MetaNet consisting of tactical networks (MSE, CEC, LINK16), DISN networks, and commercial networks. Begin development of information flow optimization technologies for dynamic channel building and global, content-based information utility maximization. Generalize the concept of metadata attribute spaces stated in the BADD ACTD, and develop the multi-dimensional vectorspace-based algebra required to achieve other AICE technical goals. Conduct Performance Analysis and Integration experiments to assess and spur improvement of technology components. ($ 19.510 Million)

- Airborne Communications Node (ACN): Continue the execution of the design phase with multiple system design teams and initiate payload design and development for a proof of concept - functional - demo in early FY 2000. Continue ACN technology integration and experimentation and conduct lab demonstrations to verify mitigation approaches/designs for high-risk areas such as EMI/cosite and antenna coupling/range. ($ 22.100 Million)

- Command Post of the Future (CPoF): The program will begin to develop CPoF technology, an integration environment, and begin work to design a series of decision experiments to test the effectiveness of the CPoF system to improve command decisions. Technology development will begin to create a new suite of human-systems interaction technology, the major technology emphasis of the program, to include work in cognitive engineering, displays and workspace design, visualization, multi-modal user interaction, and dialog management and reasoning. System integration will also begin to refine and integrate the individual technologies into a complete CPoF system for testing in simulation-based Command Post exercises. Experiment planning will begin with user representatives from the service battle labs to define operationally meaningful test problems and design a series of simulation-based decision experiments to test the effectiveness of the new technology in improving command decisions. The first version of an integrated CPoF system will be created and tested at the end of FY 1999. ($ 11.232 Million)

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(U) **FY 2000 Plans:**

- BADD ACTD: Complete the 2-year ACTD sustainment phase. ($ 7.418 Million)
- AICE: Complete the development of metadata vectorspace-based algebra and use it to develop dynamic and conditional information profiling capabilities. Continue development of advanced information management technologies including Large-Scale Dynamic Channel Building Algorithms, Global Quality-of-Service Optimization, and Information Management Services to moving entities. Demonstrate prototype MetaNet providing end-to-end quality of service across tactical, DoD DISN, and commercial IP networks, as well as DoD tactical networks. Use Performance Assessment Environment to evaluate and select highest payoff technologies for insertion and evaluation within the BADD ACTD architecture. Begin investigation of incorporating ACN as part of the MetaNet. ($ 23.391 Million)
- Complete a Phase III DDB architecture design that prototypes a single node DDB SIL. Expand the Dynamic Situation Model object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data using data-driven fusion methodologies. Extract and fuse enhanced multisensor data features over time. Include visible EO into the stored data-types. Develop and validate multiple-sensor terrain and entity phenomenology models. Validate prototype multi-sensor target phenomenology models. Incorporate automatic situation context into single and multi-sensor anomaly detection algorithms. Demonstrate an interactive prototype update service for the entity layer of the Dynamic Database. Upgrade technology products in the DDB SIL and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data and entity-level situation hypotheses. Incorporate DDB technology in XVIII Airborne Corps 525th Military Intelligence (MI) Brigade forward sensor enclave (FSE) testbed. ($ 33.308 Million)
- Command Post of the Future (CPoF): The program will produce new technology components, which will enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react. Technology will be produced to enable the commander and his staff to easily access information and quickly understand changing battlefield situations by speaking, pointing and naturally interacting with a suite of high-resolution displays in a CPoF environment. Technology will be produced to automatically generate visual presentations of battlefield information, tailored to the individual commander's background, preferences, current situation, task, and topic of interest. Different versions of these technology components will be integrated and tested in a series of simulation-based decision experiments. ($ 17.638 Million)

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- Airborne Communications Node (ACN): Conduct proof of concept manned aircraft demonstrations of competitive ACN system designs and down select to a single team for full function payload design and development. This design will be targeted to operate within the stringent environmental of the Global Hawk high altitude endurance unmanned aerial vehicle, thereby stressing the packaging technology required to meet the form, fit and function. This will enable subsets of the full functionality and design to be easily transferred to other SWAP-limited platforms like tactical UAVs. Complete final system designs and begin system integration. Conduct laboratory demonstrations of critical subsystems. ($ 31.200 Million)

(U) **FY 2001 Plans:**

- AICE: Demonstrate the capability to support real-time information flows across the MetaNet. Develop mechanisms for visualizing and understanding the macro structure of information flows supporting a large military operation. Automate the generation of information management policies based upon commander's intent. Assess military utility. Transition into pilot service and/or operational environments ($ 24.693 Million)

- DDB: Include video data into the stored data-types. Extract and fuse visible EO to extend multisensor data features over time. Develop and validate EO & video terrain and entity phenomenology models to incorporate streaming video into the mosaic display process. Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities. Continue to upgrade technology products in the DDB SIL and demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Dynamic Situation Model, and provides the user ready access to sensor history data, entity- and force-level situation hypotheses. Incrementally update intelligent DDB services in 525th MI FSE testbed. ($ 10.000 Million)

- Command Post of the Future (CPoF): The program will continue to develop and integrate new CPoF technology into a complete CPoF system to enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react. New versions of the technology components developed in FY 1999 will be integrated and tested in a series of simulation-based decision experiments. The most effective technology will be integrated into a complete CPoF system for an end-to-end demonstration of in a simulated joint exercise. Preparations will begin for an operational demonstration of the CPoF system in a joint field exercise in FY 2002. ($ 22.000 Million)

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- Airborne Communications Node (ACN): Complete full system integration, extend laboratory demonstrations across multiple subsystem components, plan extensive ground interaction and flight demonstrations with joint warfighters, and conduct multi-platform (including Global Hawk) flight demonstrations in Joint Warfighter environments. ($ 11.400 Million)

- Demonstrate the ability to automatically extract facts about potential terrorist activities form open sources data and correlate those facts to accurately model a terrorist network. ($ 20.000 Million)

- Real-time Infrastructure Capabilities Assessment (RICA) will develop a set of workarounds reasoners to speed up the effects-based targeting process by providing the capability to automatically assess an enemy's ability to compensate for a damaged component. RICA will develop an information system to enable real-time re-targeting of infrastructure targets based on damage assessment and real-time observations of the targeted systems performance. ($ 3.000 Million)

- Skylink: The program will identify and define the key components of the effort and a strategy or process for engaging with SATCOM providers and industry. Also, a detailed technical architecture will be developed to support a proof of concept experiment. The effort will focus on augmentation of TCP/IP and ATM technology for mobile tactical use, development of heterogeneous interfaces, augmentation of fixed site signaling and tracking technology for mobile sites, and development of assured service protocols. ($ 12.453 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Mar 99	Complete Military Utility Assessment of BADD Release 2.
Jun 99	Complete BADD ACTD Military Utility Assessment at Roving Sands.
Jun 99	Demonstrate single node prototype DDB technologies, to include sensor history database and computation services (registration and mosaicing) for SAR, IR, SIGINT, and MTI.
Sep 99	Test integrated Command Post of the Future system.

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Oct 99	AICE assessment environment operational.
Nov 99	Complete AICE Release 1.
Dec 99	Complete initial ACN System Design Reviews and conduct proof of concept flight demonstrations.
Dec 99	Demonstrate an interactive DDB multi-sensor history database and entity-level situation assessment service (extending the services to include EO).
Jan 00	Downselect to one ACN Team.
Mar 00	Participate in major field test experiment (Ulchi Focus Lens) operating on live and simulated data from multiple sensors.
Apr 00	Complete AICE theoretical framework.
Jul 00	Demonstrate Smart Adversary to Army.
Sep 00	Complete BADD ACTD transition to DISA, GBS Joint Program Office (JPO) and the Services.
Sep 00	Demonstrate AICE prototype MetaNet.
Oct 00	Phase III complete. Incorporate DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed.
Nov 00	Complete AICE Release 2 technology products.
Dec 00	Demonstrate an interactive DDB system that ingests raw multi-sensor data, aligns, mosaics and displays the data within a 3-D Spatio-temporal reference frame in the SIL.
Jun 01	Demonstrate a fully interactive dual-node DDB entity- and force-level situation assessment service (extending the services to include video).
Jul 01	Demonstration of Smart Adversary extended to Navy and Air Force.
Aug 01	Complete ACN Payload Integration, laboratory and antenna range tests.
Sep 01	Demonstrate COAA level analysis within major Army exercises (e.g., Advanced Warfighter Experiment -AWE).
Sep 01	Demonstrate real-time flow support, AICE MetaNet.
Sep 01	Complete AICE technology transition into pilot service or operational environments.
Oct 01	Phase IV complete. Incrementally update DDB technology into XVIII Airborne Corps 525th MI Brigade FSE Testbed. Begin preparation to expand DDB into a multi-sensor, multi-node-distributed architecture.
Oct 01	Skylink Proof of Concept experiment.
Mar 02	Complete ACN payload integration and test with Global Hawk.
Aug 02	Complete ACN field demonstrations.
Sep 02	Complete ACN transition.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, R-1 #49					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	70.165	52.258	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Simulation CST-01	29.050	26.397	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Global Grid Communications CST-02	38.519	25.861	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Defense Simulation Internet (DSI) CST-03	2.596	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it's purpose is to demonstrate and evaluate advanced simulation technologies and networking systems that will seamlessly integrate command and control functions needed for future global defense operations.

(U) The Advanced Simulation project is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation across a full range of DoD functions. As technologies mature, they are integrated, tested and demonstrated in exercise/demonstrations of varying size and complexity. Within this project, the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies to provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. These technologies will be transitional to service and joint simulation developers at the end of FY 1999.

(U) The Global Grid Communications project is developing and demonstrating advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program requires the design, adaptation and development of new internetwork protocols. The three main efforts in this project are: (1) the Joint Task Force Advanced Technology Demonstration (JTF-ATD) of a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations from Major Theater War (MTW) to Operations Other Than War (OOTW) capable of being established and operational in days; (2) the Warfighter's Internet program which develops and demonstrates a

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mobile wireless backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air, and (3) the Broadband Information Technology (BIT) program which seeks to develop all-optical multiple wavelength transmission and networking technologies. These technologies will transition to the Services at the end of FY 1999.

(U) The goal of the Defense Simulation Internet (DSI) program is to research, develop and test at scale (worldwide), a network infrastructure capable of enabling distributed, real-time, multi-media (video, voice, shared data and work spaces) simulation that will seamlessly integrate all simulation, modeling, command and control functions from early design to battle rehearsal enroute to the conflict. The DSI transitioned to the Defense Information Systems Agency (DISA) Defense Information System Network (DISN) on a fully reimbursable basis at the end of FY 1998.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	74.212	56.114	29.750	31.049
Current Budget	70.165	52.258	0.000	0.000

(U) **Change Summary Explanation:**

FY 1998	Decrease reflects reduction of the Warfighter's Internet and SBIR reprogramming adjustments.
FY 1999	Decrease reflects transition of Defense Information Infrastructure Common Operating Environment (DII COE) to AITS JPO.
FY 2000/01	Decrease reflects transition of the STOW ACTD, JTF ATD, Broadband Information Technology and Warfighter's Internet programs to the Services.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Simulation CST-01	29.050	26.397	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The strategic environment in which the United States operates will require Joint Forces to operate across the full spectrum of conflict. At the same time, resources will continue to shrink, requiring the Department to search for the most cost effective means to perform the full spectrum of defense functions. To support the National Military Strategy, the Advanced Distributed Simulation (ADS) program is developing advanced simulation technologies that provide a seamless synthetic battlespace that will enable high fidelity simulation for Joint/Service readiness training and mission rehearsal. Within the ADS Programs the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies that provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. The STOW ACTD technology development includes Synthetic Environment, Synthetic Forces, System Design and Integration and Advanced Network components. The Synthetic Environment component concentrates on the creation of large scale digital environments including, representation of dynamic terrain and targets, weather and environmental phenomena, as well as seasonal and diurnal variations. The Synthetic Forces component creates a scalable, computer-generated joint military force that is both representative and behaviorally credible. This platform-based simulation includes models of command forces as well as intelligence sensors and their related platforms. The high fidelity of the computer-generated forces provides the capability to resolve battle outcomes at the weapon system level of detail. The System Design and Integration component develops the overall DoD High Level Architecture (HLA)/ Run Time Infrastructure (RTI) compliant system design, interfaces to C4I systems, distributed exercise management, data collection and after action review applications. These technologies will transition to Service and joint simulation developers at the end of FY 1999.

(U) The Advanced Simulation Technology Thrust (ASTT) program builds on the STOW Program and develops the advanced simulation technologies required to support the next generation of DoD simulation systems, such as the Joint Simulation system (JSIMS). The goal of the ASTT program is to solve the core technology problems required to significantly increase the flexibility of simulations while simultaneously reducing the requisite resources (cost, personnel and time). DARPA's ASTT technology development efforts complete in FY 1999.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Based on lessons learned from Unified Endeavor 98-1 and USACOM revised operational requirements, improved the STOW prototype and provided operational demonstrations of an increased capability to the joint warfighter in support of USACOM and the services. This included enhancing the warfighter's capabilities to employ high fidelity, platform level simulations for a variety of missions, by improving technology, tools and applications. Integrated new/improved synthetic environments, synthetic forces, and networking technologies as well as products developed in conjunction with the United Kingdom's Synthetic Environment Program. Continued transition of STOW technologies to JSIMS and other DoD users. ($ 12.619 Million)

- Continued development of Advanced Simulation Technologies in the ASTT program to support JSIMS, WARSIM and other service simulations. Technology efforts included: Adaptive multi-skilled Synthetic Forces; scalability to greater than 20,000 objects; distributed multi-cast data collection on large amounts of data; rapid generation of computer generated forces and alternative methods of Synthetic Force generation; single synthetic environments database abstraction to accommodate multiple simulation requirements; initial multi-resolution modeling techniques. ($ 11.521 Million)

- Continued to develop and demonstrate Course of Action Analysis (COAA) technology based on advanced simulation technology and related modeling techniques. Extended FY 1997 effort to provide a tightly coupled COA development/COA analysis environment that shortens the overall planning cycle by 50%. Evaluated: extension of COAA technology to other Services; next generation COAA analysis techniques (such as advanced adversarial reasoning); and the techniques necessary to tightly integrate the mission planning/mission rehearsal/mission execution monitoring end-to-end process as it applies to land combat. ($ 4.910 Million)

(U) **FY 1999 Plans:**

- Continue to refine and transition prototype technologies in support of USACOM and the Services. Demonstrations will focus on the representation of a seamless land/sea/air warfighting synthetic environment with an ever-increasing degree of realism, and C2 interfaces, to support Service and joint operational training and analyses while retaining the arbitration of battle outcomes at the platform level of

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resolution. Transition technology, tools and applications in support of the next generation of DoD simulations. The STOW ACTD will conclude by end of FY 1999. ($ 14.128 Million)

- Continue to develop high risk Advanced Simulation Technologies required by, and in coordination with, JSIMS and other Service simulations (e.g. WARSIM) to meet their respective Full Operational Capability (FOC) requirements. Technology efforts will include: the rapid composition effort has developed the algorithms to automatically translate exercise requirements into simulation requirements and to automatically compose the resulting simulation. The synthetic force component has created a scalable framework for modeling the C2 hierarchical and collaborative decision-making process through the Joint Task Force level required to automatically generate and evaluate multiple courses of action. The synthetic environment component has developed consistency algorithms to support the rapid editing of environmental data (pre-exercise & run time) while maintaining temporal and spatial consistency within and across all environmental domains (air, land, & ocean). The scalable executing system component has redefined the distributed simulation paradigm by centralizing the simulation objects and distributing the interfaces and by applying advanced latency reduction techniques and dynamic data distribution algorithms to achieve scalable architectures necessary to support large scale, distributed simulations. Continue to transition all technologies to JSIMS, et al. ($ 12.269 Million)

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Jun 99	Support USACOM JE99-01.
Sep 99	Complete the development, integration and documentation of the STOW prototype. Complete final transition of STOW Technology to JSIMS/JWARS and the military service.
Sep 99	Complete the development of ASTT technologies and proof of principles.
Sep 99	Transition ASTT simulation technologies to the JSIMS and the Service simulation developments.
Sep 99	Program completion and close out.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-02					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Global Grid Communications CST-02	38.519	25.861	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project develops and demonstrates advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program will demonstrate that information technologies can be integrated with both advanced optical, high performance networks and mobile, wireless tactical. This will provide multimedia information flows, efficient use of bandwidth, and minimal logistical requirements for warfighting, disaster relief, and emergency medical support. The program requires the design, adaptation and development of new internetwork protocols. These technologies will be transitioned to the Services at the end of FY 1999.

(U) The goal of the Joint Task Force Advanced Technology Demonstration (JTF ATD) is the development of rapid crisis response capabilities for the Commander Joint Task Force (CJTF) in support of a wide range of situations from Major Theater War (MTW) to Operations Other Than War (OOTW). The JTF ATD will create a supportable, global grid-based C4I technology base that will deliver an exponential increase in decision support capability to the theater CINC and JTF commander during crisis planning, rehearsal, and execution. The JTF ATD will provide an initial set of composable services that enables system developers with the ability to provide common servers and application suites that supports the Warfighters needs.

(U) The goal of a Warfighter's Internet is to expand open architecture and internetworking technologies into the mobile wireless domain to: provide a robust, automatically reconfigurable, internetworking capability; and, to support warfighters in rapid deployment and highly mobile scenarios. This will be accomplished as a joint effort with the Airborne Communications Node program and will enable a backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air. Provision for multimedia information flows, efficient use of bandwidth, and minimal logistical requirements are key objectives that require the design, adaptation and development of new network protocols for mobile, wireless battlefield networks. Technology development and demonstration will focus on networking technologies to integrate existing and developmental communication systems and networks using airborne nodes such as Global Hawk (Airborne Communications Node). A scalable internet will be demonstrated in conjunction with joint service exercises and advanced warfighting experiments.

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(U) The Broadband Information Technology (BIT) program seeks to develop all-optical multiple wavelength transmission and networking technologies. Specifically, this program has four goals: (1) a billion bit per second bandwidth on demand, independent of the analog and digital nature of the applications, (2) rapid, nearly transparent reconfiguration of network routing, (3) multiplexing of continuous transmission rates (bit rates from thousands of bit per second to billion of bits per second), and (4) transmission of analog and digital signals in a single fiber.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- The Broadband Information Technology project demonstrated multi-wavelength network management and control in local area testbeds. ($ 6.195 Million)
- Broadband Information Technology projects demonstrated 40 billion bits per second cross-connect switching and 32 channel transceiver chip. ($ 8.700 Million)
- Continued analysis and report on economics of multi-wavelength network architecture and technology for local area optical networks. ($ 1.300 Million)
- Developed several Common Object Request Broker Architecture (CORBA) compliant composable services and developed a composer that provides system developers automated code generated servers that support the Warfighter's crisis planning applications. Also supported the extension of the infrastructure, architecture, servers and applications across computing platform classes and to emerging and related programs within the DARPA ISO development environment with the composable services. Demonstrated the composable services at the DARPA Information Superiority Technology Integration (ISTI-98) event. ($ 16.599 Million)
- Completed design and development of first phase of mobile, wireless network software and protocols, self-organizing cross links, network and mobility management, security, application interfaces, signaling protocols and RF subsystem integration and engineering based on the DARPA-led, joint Service study that defined technical requirements and network systems architecture for a Warfighter's Internet/joint tactical internetwork. Integrated technology with the Airborne Communications Node payload requirements/design. Continued Advanced

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Digital Receiver and radio frequency microelectromechanical systems (RF MEMS) Tunable Filters technology efforts. Initiated time varying magnetic flux antenna investigation. ($ 5.725 Million)

(U) **FY 1999 Plans:**

- Broadband Information Technology project will demonstrate full operations, multi-wavelength, experimental, system network including interoperability among testbeds distributed across several geographic domains. ($ 5.564 Million)
- Deliver JTF ATD developed composable services and provide infrastructure support to the Technology Integration Center (TIC) in this last year of the JTF ATD. Move the JTF ATD's integration and experimentation environments to the TIC. Extend and finalize the composable services system developers tools and transition the composable services and tools to the TIC repository. Execute Technology Integration Experiments (TIEs) with several DARPA ISO projects and at least the JL and ACOA ACTDs. In support of these activities hold several training sessions (boot camps) for prospective adopters of the composable services. ($ 5.518 Million)
- Warfighter's Internet project will integrate technology with the Airborne Communications Node developments. In coordination with Airborne Communications Node, initiate test & demonstration of airborne cross links, wireless backbone using manned aircraft; continue to develop network protocols and integrate into commercial products; integrate legacy and emerging radios in mobile, wireless internet. Demonstrate increased warfighter capabilities as part of combined ACN demonstration in late FY 1999. Complete Advanced Digital Receiver technology development and integration. Continue RF MEMS Tunable Filter, programmable INFOSEC, advanced digital transmitter/external power amplifier and antenna technology developments. ($ 14.779 Million)

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
3Q FY99	Deliver JTF ATD composable services and system developers tools.
3Q FY99	Demonstrate 20 gigabit per second, multi-channel, multi-media, and large-area network.
4Q FY99	Field demonstration of mobile wireless network technologies coordinated with BADD, Extended Littoral Battlespace (ELB) and Small Unit Operations experiments.
4Q FY99	Complete Advanced Digital Receiver and RF MEMS Tunable Filters upgrades.
4Q FY99	Deliver JTF ATD composable services and developers tools to the TIC repository.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, R-1 #50

COST (*In Millions*)	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	160.881	209.971	232.319	211.893	236.586	251.482	242.096	251.896	Continuing	Continuing
Guidance Technology SGT-01	35.275	34.189	19.666	12.231	22.633	32.964	33.764	36.564	Continuing	Continuing
Aerospace Surveillance Technologies SGT-02	19.999	65.899	71.012	70.229	73.517	90.686	77.500	84.300	Continuing	Continuing
Air Defense Initiative SGT-03	20.170	25.257	40.350	38.680	35.460	35.000	38.000	38.200	Continuing	Continuing
Sensor and Exploitation Systems SGT-04	85.437	84.626	101.291	90.753	104.976	92.832	92.832	92.832	Continuing	Continuing

(U) **Mission Description:**

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The six programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

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(U) The Air Defense Initiative is an on-going activity whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of US assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; providing near-real-time exploitation of imagery data; and semi-automated target recognition and tracking.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	167.184	213.154	232.646	204.718
Current Budget	160.881	209.971	232.319	211.893

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects reprogramming for general reductions in PL 105-56, inflation transfer and SBIR reprogramming.
FY 1999 Decrease reflects Congressional reductions.
FY 2000 Reduction reflects Agency restructuring of priorities.
FY 2001 Increase reflects increased Agency emphasis being placed on Sensors and Exploitation Systems.

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APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defense-wide
BA3 Advanced Technology Development

R-1 ITEM NOMENCLATURE
Sensor and Guidance Technology
PE 0603762E, Project SGT-01

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	35.275	34.189	19.666	12.231	22.633	32.964	33.764	36.564	Continuing	Continuing

(U) **Mission Description:**

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the ability of GPS users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. The Phase 2 was structured and continues as a competitive program with two prime contractors. GGP applications include the Army Tactical Missile System and the Multiple Launch Rocket System.

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(U) This program also will increase the ability of GPS users to operate effectively in presence of enemy jamming or countermeasures. It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability of GPS signals to users in the presence of enemy jamming. The considerably increased transmit power of the APL fights off the effects of jamming on DoD receivers. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The project assesses two key challenges. First, it will demonstrate non-Keplerian orbit predictions of the APL and show that only software modifications are needed for GPS user receivers. Second, the APL must also accurately navigate using GPS satellites in the presence of jamming. Accordingly, this project provides for the design, development and demonstration of a low cost, all digitally controlled GPS receiver with a space time adaptive beamforming anti-jam antenna. A digital adaptive beamformer with advanced algorithms is capable of supporting greater the 50 dB nulls against up to six different jammers.

(U) The Micro-Electromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance appropriate MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution or near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate in real-time the distributed multi-platform emitter collections using existing or planned tactical radios with advanced network management and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self-contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly

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dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Continued fabrication and began integration of GGP Phase 2 hardware and software. ($ 18.715 Million)
- Established a second source for GGP, thereby continuing as a competitive program (Congressional). ($ 6.000 Million)
- Demonstrated proof of concept MEMS devices. ($ 3.290 Million)
- Initiated Advanced Tactical Targeting Technology (AT3) design and development. ($ 6.650 Million)
- Completed autonomous landing guidance (ALG) system installation on C-130H3, and conducted operational flight tests. ($ 0.620 Million)

(U) **FY 1999 Plans:**

- Perform final integration and testing of GGP units; deliver units; proceed with adaptive signal processing/beamformer to null jammers; evaluate feasibility of airborne GPS pseudolites. ($ 6.516 Million)
- Maintain a second source for GGP, thereby continuing as a competitive program (Congressional). ($ 6.500 Million)

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- Iterate MEMS foundry inertial sensor fabrication and initiate preliminary sensor testing. ($ 9.502 Million)
- Complete AT3 preliminary design and system simulation. ($ 11.671 Million)

(U) **FY 2000 Plans:**

- Complete evaluation of the feasibility of pseudolites; continue and complete adaptive signal processing and digital beamformer. ($ 4.000 Million)
- Complete MEMS integration with navigation software and demonstrate INS operation. ($ 7.000 Million)
- Complete AT3 brassboard fabrication and ground tests. ($ 8.666 Million)

(U) **FY 2001 Plans:**

- Complete refinement and evaluation of elements of the pseudolite network. ($ 2.500 Million)
- Complete demonstration of MEMS INS operation. ($ 6.000 Million)
- Conduct AT3 flight tests. ($ 3.731 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) Schedule Profile:

Plan	Milestones
Jun 99	Deliver GGP units to the Government.
Aug 99	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Sep 99	Deliver engineering model MEMS accelerometers.
Sep 99	Complete integration of an adaptive GPS antenna array.
Feb 00	Complete test and evaluation of GGP Phase 2 units.
May 00	Complete integrated demonstration of miniature GPS receiver and adaptive antenna.
Jun 00	Complete AT3 brassboard fabrication and begin ground tests.
Sep 00	Complete AT3 ground tests.
Nov 00	Test and deliver brassboard MEMS inertial navigation system.
Feb 01	Initiate AT3 flight tests.
Mar 01	Complete Government evaluation of the robust MGR.
Sep 01	Complete AT3 flight tests.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technologies SGT-02	19.999	65.899	71.012	70.229	73.517	90.686	77.500	84.300	Continuing	Continuing

(U) **Mission Description:**

(U) This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate the targeting and imaging technologies to enable a low-cost, all weather, day/night precision targeting approach against moving or stationary targets at millimeter wave (W band) frequencies. The technologies investigated will include active and passive techniques to achieve high resolution targeting (low circular error probability (CEP)) and imaging (1-3 m). An objective system could be used for weapons targeting, high resolution imagery, and battle damage assessment. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Radio Frequency (RF) Tags will develop the technology to allow radars (Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to covertly receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communicating with Special Operations Forces and other operatives/personnel behind enemy lines. In addition, the RF tag developed can be used to identify and locate coalition forces and covertly track red forces. Additionally, the RF Tag can be used against enemy forces by modifying their return radar signal to produce virtual US ground and/or air forces. The net effect is substantially enhanced US situational awareness and simultaneously degraded enemy force situational awareness.

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(U) The Adaptive Spectral Reconnaissance Program (ASRP) will establish the technical underpinnings for real-time detection of tactical targets employing concealment, camouflage, and deception using hyperspectral sensor data from visible through long wave infrared spectral imagery. The program will develop the algorithms, models, phenomenology and advanced long wave infrared sensor technology, and verify the development on an airborne testbed. The testbed will serve as a platform to verify technical developments and conduct demonstrations of a real time tactical directed area search capability. ASRP will employ visible or near infrared (VNIR)/short wave infrared (SWIR)/long wave infrared (LWIR) spectrometers, an on board data processor with multiple algorithms, and high resolution day/night imagers to provide cues and high resolution imagery products to the analyst in support of the counter-countermeasure and deception (CC&D) mission. The developed system will be demonstrated on the ASRP testbed and subsequently on a surrogate unmanned aerial vehicle (UAV) platform.

(U) In FY1999, the Tactical Radar program is being assimilated by the Discoverer II program because of the close, inherent relationship of the two programs, and the dependency of the Discoverer II program on the success of technical advances being pursued by the Tactical Radar effort.

(U) The Discoverer II program is a DARPA, Air Force and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance and precision geolocation support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the Defense Science Board (DSB) Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to both meet warfighter needs at lower cost, and to enhance system maturity thereby facilitating a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology demonstration program. In the first phase industry will conduct detailed trade studies necessary to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2003 timeframe that shows the ability to achieve the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the Tactical Radar program will be exploited, and other risk reduction initiatives will be undertaken to ensure Discoverer II system development can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode (Ground Moving Target Indication/Synthetic Aperture Radar (GMTI/SAR)) space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning radar modules (10x reduced power requirement), and 3) sparse band processing for

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data compression allowing on-ground processing with .5Gbps links, and Automatic Target Recognition (ATR) quality (.5m) range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (3m or less geolocation accuracy theater wide). If industry trade studies, informed by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, phase two will be entered: the actual building and flying on-orbit of two GMTI/SAR technology demonstration satellites. That demonstration will validate the technical feasibility of: space-based GMTI detection and tracking, and moderate resolution SAR imaging, using a small, low-mass, beyond-current state-of-the-art radar antenna; theater or joint task force commander tasking of overhead GMTI and SAR collection; near-real-time, direct downlink to theater of overhead GMTI and SAR collection, using tactical ground stations otherwise planned for use with our U-2 and Unmanned Air Vehicle (UAV) airborne platforms; and, collection of high-resolution terrain mapping data, anywhere around the globe. A "go-ahead" decision to proceed with follow-on acquisition would be made after the completion of the Discoverer II demonstration program, sometime after FY2004.

(U) The Novel Antennas Program is developing novel techniques to produce small, lightweight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures are explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs. During FY1999, the distributed architecture has been refined to include spectrum supremacy, the ability to deliver novel radio frequency (RF) capabilities to organic ground combat vehicles (e.g. Abrams tanks, HMMWVs).

(U) The Counter-Underground Facilities program will identify, research, develop and demonstrate high leverage technologies for characterizing and functionally neutralizing underground facilities. Such structures are increasingly employed to hide manufacture and storage of offensive weapons, including chemical, biological and nuclear weapons. The project will begin by investigating critical phenomenological unknowns related to observable signals generated by underground facilities and the backgrounds in which such signals would be detected. A series of experiments would then ensue to resolve the critical unknowns and deepen the national capability to model such structures and predict which, if any, reliable signals might be present and detectable for representative targets. Sensor techniques would then be developed and demonstrated to exploit these reliable signatures. Both remote and proximal types of technologies will be studied. Candidate technologies include, but are not limited to, laser vibrometry, low frequency electromagnetics, multi/hyperspectral imaging, seismic/acoustic imaging, laser velocimetry and micromechanical systems for close access tagging and sensing.

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(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or satellite pulse Continuous Wave (CW) radar to detect, locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The Large Millimeter Wave Telescope (LMT) is a Congressionally mandated program to develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) **Program Accomplishments and Plans:**

(U) **FY1998 Accomplishments:**

- The Millimeter Wave Targeting & Imaging System (MMWTIS) program - Completed panel review and program assessment which shifted program from Passive MMW to Millimeter Targeting and Imaging. Issued Solicitation, evaluating and awarding concept development efforts. Initiated 94 GHz signature measurements and analysis. Refined requirements and subsystem and technical specifications for transmitter and component technology. Refining 3D Synthetic Aperture Radar (SAR) algorithms. Program successfully achieved all technical milestones of targeting and imaging. ($ 4.600 Million)

- Radio Frequency (RF) Tags program - Performed analyses for multiple concepts of operation to include remote communications of sensor data from unattended ground sensors, data communications from Special Operations Forces (SOF), geo-registration of Synthetic Aperture Radar (SAR)/Moving Target Indicator (MTI) imagery, and communications of geolocation and other data between dispersed operating units. System design for each operational concept was conducted, and fabrication of brassboard Radio Frequency (RF) tags, modifications

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to airborne SAR/MTI processors and ground stations were completed. Tests were performed with the Joint Surveillance Target Attack Radar System (JSTARS) to define an RF tag system architecture and functionality. Flight tests were conducted with SAR tag designs to demonstrate a SAR tag and to design signal and image processing software. Development was initiated for ID-only and data extraction tags to be tested with SAR and MTI platforms. A CONOPS/Requirements study was completed to establish the system CONOPS, utility, value added and requirements, and a study of radar platform characteristics was initiated to evaluate suggested platforms. ($ 4.798 Million)

- Adaptive Spectral Reconnaissance program - Developed system concepts and sensor specifications. Prototyped system (NVESD Twin Otter) in flight, collecting data. Coordinated concept verification data collections occurring with Air Force Research Lab, Naval Research Lab Spectral Information Technology Assessment Center (SITAC), and Aerospace Corporation. Conducted detailed data/imagery analysis to include multiple target sets, multiple algorithms, receiver operating characteristic generation, and phenomenology assessment. Completed concept definition to include algorithm development, mission utility analysis, operational concept, sensor specification development, test plan preparation, and data analysis. Established transition partners with Army (Aerial Recce Low/Aerial Common Sensor PM) in terms of outyear POM and validated developed requirement. Worked transition issues with Air Force Unmanned Air Vehicle (UAV) Battle Lab and Air Force Recce Special Project Office (SPO). ($ 3.322 Million)

- Tactical Radar program - Developed initial algorithms supporting aerospace-based ground moving target indication (GMTI) using low-cost, light-weight, multiple phase center/receive channel antenna and 548 Mbps Common Data Link (CDL). Established feasibility of high-throughput, GMTI collection (>800 km2/sec collection rate, sustained over >6 min). Established feasibility of achieving <10 kph Minimum Detectable Velocity (MDV) for ground targets. Developed initial algorithms supporting GMTI collection performance while simultaneously collecting undergraded synthetic aperture radar (SAR) phase history data, in 3m resolution mode. Established feasibility of achieving discontinuous GMTI track correlation, and developed initial algorithms enabling GMTI target tracking. Conducted selective/limited GMTI data collection using existing airborne SAR platforms. ($ 4.395 Million)

- Large Millimeter Wave Telescope (LMT) - Source selection for systems integration contractor. Preliminary system design completed. Millimeter wave instrument demonstrated. Preliminary assessment of pointing system. Temporary road to site completed. ($ 2.884 Million)

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(U) **FY 1999 Plans:**

- Millimeter Wave Targeting & Imaging System (MMWTIS) – Complete concept development studies. ($ 1.000 Million).
- Radio Frequency (RF) Tags program - Complete development and testing of ID-only RF Tags for use with Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) airborne radar platforms. Continue design of data extraction tags for low data rate communications applications. Conduct design trades for miniaturizing the tags. ($ 8.980 Million)
- Adaptive Spectral Reconnaissance program – Develop end to end spectral system model to include real/synthetic imagery generation, atmosphere/path radiance components, sensor models, and algorithm segments. Conduct joint data collects in Southeastern US (Eglin AFB), Southwestern US (National Training Center, Yuma Proving Ground), littoral zone (Bridgeport Marine Corps Station) and out(side) of the continental United States (OCONUS) (location to be determined). Continue analysis of all data, looking at algorithms, models and fusion methodology. Develop improved long wave infrared (LWIR) Hyperspectral sensor with high resolution thermal imager. Develop spectral signature phenomenology and database, and analyze large data sets. ($ 4.046 Million)
- Discoverer II program – Commence Phase I: Award multiple system integration (SI) contracts (2QFY99). Support SI contractor trade studies to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2004 timeframe that shows the ability to achieve the proposed objective capability. SI contracts will consist of a basic contract and an option to continue. The basic contract period of performance will extend from contract award to the completion of the second Interim Evaluation Review (IER) (including the closure of all action items). The option will conclude Phase I, starting after the second IER, and running to the third and final IER. The SI contractors will select and schedule milestones, including the three IERs, in their Integrated Master Plan/Integrated Master Schedule. Fixed payments for work completed will be tied to successfully completing these milestones. The Government will establish mission priorities and capabilities shortly after the first IER for feedback into the design trades. Support jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing, and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 31.475 Million)
- Novel Antennas program will pursue data collection, and will demonstrate algorithm performance against emitters in a realistic interference environment (urban, desert and hilly deciduous forest). Urban and non-urban environments will be explored. Distributed architectures will be developed and assessed, supporting hardware will be developed and demonstrated, and algorithm performance will be

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evaluated. The integrated system design will be developed. An experiment will also be conducted to determine the utility/synergy of close access, distributed collection capability into a distributed architecture. Networked sensors, which leverage software reprogrammable radio technology, will be employed to assess the utility of distributed architectures. ($ 13.526 Million)

- Counter-Underground Facilities program will convene a signal hypothesis working group consisting of the nation's experts in a variety disciplines critical to the counter underground facility problem including seismology, acoustics, low frequency electromagnetics, geology, and others. The working group will identify and model critical underground facility signatures, propagation phenomenology and backgrounds. It will also identify critical unknowns and define experiments to resolve them. Experiments, data analyses, and detailed modeling activities will begin. ($ 5.372 Million)

- Large Millimeter Wave Telescope (LMT) program – Complete preliminary critical system design. Complete metrology system design. Continue site characteristic measurements through seismic and wind monitoring. ($ 1.500 Million)

(U) **FY 2000 Plans:**

- Radio Frequency (RF) Tags program – Develop a miniaturized analog RF tag; Conduct a Critical Design Review (CDR) for a digital RF tag; continue development of data encoding and extraction algorithms. ($ 5.851 Million)

- Adaptive Spectral Reconnaissance program - Complete end to end spectral system model to include real/synthetic imagery generation, atmosphere/path radiance components, sensor models, and algorithm segments. Verify all data collects with model and provide predictive performance of future operational use. Complete analysis of all data. Collect testbed data with improved long wave infrared (LWIR) Hyperspectral sensor and with high resolution thermal imager and validate its performance in conjunction with the model. Provide demonstrations to users, and initiate transition process. Conduct demonstrations on unmanned air vehicle (UAV) surrogate platform. ($ 4.000 Million).

- Discoverer II program – Continue ground moving target indication (GMTI) radar satellite design efforts for three or four system integration (SI) contractor teams. Continue risk reduction activities in key areas, to include: antenna design and fabrication, advanced signal processing, and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 50.661 Million)

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- The Novel Antennas program - The Novel Antennas program will transition technology to a ground based military system for real-time urban, desert, mountain and littoral operations. Adjunct platforms will be pursued for technology transfer and system integration. ($ 1.500 Million)

- Counter-Underground Facilities program - The Counter-Underground Facilities program will continue analysis and experimentation on key observables and backgrounds. Robust modeling efforts will be initiated in critical areas previously identified, such as seismic propagation, effluent spectroscopy, and other related areas. Sensor system studies will be performed to identify critical technology initiatives, to include induced observables and other novel characterization approaches. Sensor and technology development will commence. ($ 9.000 Million)

(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags program – Complete brassboard digital RF tag; conduct operational tests of digital and miniaturized analog RF Tags in a military scenario. ($ 4.129 Million)

- Discoverer II program - Commence Phase Two: System Integration (SI) contractor(s) complete(s) detailed design of ground moving target indication (GMTI) radar demonstrator system for the 2004 timeframe that will validate the feasibility of achieving the Discoverer II program objective. Conduct critical design review (CDR) for system detailed designs. Initiate procurement of long-lead items for two Ground Moving Target Indication(GMTI)/Synthetic Aperture Radar (SAR) demonstration satellites. Continue on-going signal processing and target tracking algorithm development. Continue software demonstrations. Support jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing and exploitation software. Conduct mission utility analyses and concept of operations studies. ($ 53.100 Million)

- The Counter-Underground Facilities program will continue robust phenomenological modeling and experimentation. Selected sensors and characterization approaches will continue development. Component and system testing will begin on the most mature approaches. Field measurements will be taken to verify sensor performance and background/propagation models at selected underground facility sites. ($ 8.000 Million)

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- Non-Linear Radar Communications Mapper program: Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camouflage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development. ($ 5.000 Million)

(U) **Other Program Funding Summary Cost:** *(In Millions)*

Passive Radio Frequency Tags:

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	1.0			

Adaptive Spectral Reconnaissance:

Source	FY 1998	FY 1999	FY 2000	FY 2001
DARO	4.0			
Army		4.0	4.0	2.0

Discoverer II:

Source	FY 1998	FY 1999	FY 2000	FY 2001
NRO	14.0	14.9	29.2	54.2
Air Force		15.5	28.7	67.2

(U) **Schedule Profile:**

Plan	Milestones
Radio Frequency (RF) Tags:	
Apr 99	Complete Radar Platform Analysis.
Jun 99	Complete ID-only Tags, radar/processing modifications.
Jun 00	Conduct Critical Design Review (CDR) for miniaturized analog Radio Frequency (RF) Tag.

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Sep 00	Conduct CDR for digital RF Tag.
Sep 01	Conduct field exercise with miniaturized analog RF Tag.

Adaptive Spectral Reconnaissance:

Mar 99	Award LWIR spectral and thermal high resolution imager system development contract.
Jul 99	Conduct Preliminary Design Review (PDR) for LWIR sensor – downselect as necessary.
Oct 99	Conduct CDR for LWIR sensor.
Aug 00	Complete final visible or near infrared (VNIR)/short wave infrared (SWIR)/long wave infrared (LWIR) flight tests.

Discoverer II:

Mar 99	Award Multiple Phase I SI Contracts.
Mar 99	Interim Evaluation Review (IER) #1.
Jun 99	Polyphase Channelizer CDR.
Jun 99	Ground Moving Target Indicator (GMTI) Tracker Software (S/W) Release.
Dec 99	Polyphase Channelizer Demo.
Dec 99	Electronically Steered Array (ESA) Transmit/Receive (T/R) Thread Test.
Dec 99	Frequency Allocation/Filing.
Dec 99	Terrain Mapping Error Model/Budget.
Mar 00	Interim Evaluation Review (IER) #2.
Mar 00	Award Continuation Option to Selected system integration (SI) Contractor(s).
Jun 00	ESA Brassboard Demo.
Jun 00	Select Final Design(s).
Mar 01	SI Contractor(s) Critical Design Review (CDR).
Jun 02	Common Data Link (CDL) Space-Qualification Mod.
Dec 02	Begin Spacecraft Integration.
Sep 03	Launch Satellite #1.
Dec 03	Launch Satellite #2.
Sep 04	Joint Program Termination.

Novel Antennas:

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Apr 99	System specification complete.
Sep 99	Demo system completed.
Apr 00	Final data collection.
Jul 00	Wideband link demonstration.
Sep 00	Transition.

Counter-Underground Facilities:

Jun 99	Preliminary phenomenological experiments defined.
Jan 00	First phase of signal/background experiments conducted.
Jun 00	Model verification complete. Sensor system development initiated.
Aug 01	Conduct sensor demonstrations.

Non-Linear Radar Communications Mapper Program:

Aug 01	Complete initial assessment of non-linear scattering of communications equipment.

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	20.170	25.257	40.350	38.680	35.460	35.000	38.000	38.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) program, the Low-Cost Cruise Missile Defense (LCCMD) program, the Air Directed Surface-to-Air Missile (ADSAM) program, the Adjunct Airborne Early Warning (AEW) program, and the Micro-Electro Mechanical (MEM) antenna (MEM-tenna) program.

(U) The SAR ECCM program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The LCCMD program will employ emerging missile seeker technologies to provide affordable approaches to defeat a proliferated threat of low cost delivery platforms. These low cost delivery platforms include cruise missiles, unmanned air vehicles, fixed wing aircraft and helicopters. These platforms are capable of conducting surveillance, performing jamming, and dispensing chemical and biological warfare agents. While the performance of these platforms is limited, when employed in large numbers, they have the potential to overwhelm our current inventory of high performance and expensive missile systems and take them away from other important missions for which they are better suited. The LCCMD program will focus on the development of affordable seekers, which are better, suited to this threat. The program is currently exploring six candidate seeker concepts. These six concepts will be narrowed down through a process of analysis, laboratory testing, and ground testing, captive flight-testing and live fire testing. A modified Miniature Air Launched Decoy (MALD) will serve as the host interceptor platform for the live fire testing. Systems successfully completing live fire testing will be transitioned to the military services.

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(U) ADSAM: The purpose of this joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, difficult to detect targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such difficult to detect targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems. This live fire demonstration program uses an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by DARPA and AMCOM, known as the HUMRAAM. This demonstration program also supports the Marine's ongoing HUMRAAM program, called the Complimentary Low Altitude Weapons System (CLAWs), by allowing them to quickly progress from concept development through demonstration/validation in less than 1 year. Early successes with the HUMRAAM have led the Marines to include its further development and acquisition in their FY 2000 POM, and the Army to conduct two FY 1998 live fire tests.

(U) The Adjunct Airborne Early Warning (AEW) program will demonstrate the feasibility of ultra-lightweight, multi-aperture, multi-function radar technology in UAVs. A UAV outfitted with this technology could provide lower cost (factor of 20), continuous air and ground surveillance of low intensity areas such as no-fly zones and peace keeping areas. Such capability could supplement traditional AWACS and E2-C, and reduce the requirement to forward base large numbers of manned aircraft for these purposes. This program will also support the demonstration of the ability to get an order of magnitude more ground coverage in a GMTI mode through very wide-band off-board communications and large numbers of phase centers. The key technologies to be used are high efficiency solid state transmitters, composite lightweight integrated antennas, and advanced mode control/interleaving algorithms. Concepts will be explored which use common components to perform both the AEW mission (at the reduced ranges appropriate to this concept), and air-to-ground modes. The latter will support networking concepts, which reduce cost and enable precision moving surface target engagement.

(U) The MEM-tenna program will develop an ultra-low cost; lightweight phased array antenna based on MEMs phase shifters and Digital Mirror Device (DMD) technologies. MEM technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs FET phase shifters, while also having low insertion losses. Hard-wired beam steering control and RF manifolds are replaced by optical and RF space-fed configurations. Using these technologies, very large-scale electronically scanned arrays (ESAs) can be developed for airborne, ship- and space based applications. Phase shifter designs incorporating MEM technology are being developed, and these will be incorporated into a prototype ESA having 10000 antenna elements, operating at X-band.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- SAR ECCM: The study panel updated their analyses of intelligence, surveillance and reconnaissance (ISR) SAR ECM vulnerability and candidate ECCM technique performance. Low cost ECM techniques were analyzed and synthetic data was generated to provide a baseline for ECCM algorithm development. Data was collected against ECM threats with an operational ISR system. Algorithm development and performance analysis of ECCM techniques applicable to a broad range of of ISR radars has begun. ($ 5.238 Million)

- LCCMD: Six seeker efforts were initiated during this year. The noise radar seeker contract to perform a captive flight test was initiated. The noise radar contractor successfully passed a System Requirements Review milestone. The Micromechanical Electromagnetic (MEMS) Electronically Steerable Array (ESA) seeker contract to perform risk reduction testing was initiated. The MEMS ESA contractor conducted design trades and analyses during this period. The laser seeker and infrared seeker contracts were initiated to perform seeker concept development studies and limited laboratory testing. The optical ESA antenna and UHF antenna contracts were initiated to perform antenna concept development and limited laboratory testing. The four concept development contractors presented their detailed program plans and concepts at kick-off meeting with the Government. ($ 10.060 Million)

- ADSAM: Two successful "dry runs" of the complete ADSAM architecture were conducted in 2nd QTR FY 1998. During the 3rd QTR two tests were conducted in which HUMRAAM missiles were launched against low-flying cruise missile targets. A live fire test was accomplished during the 4th QRT using a live warhead AMRAAM missile. Following completion of this demonstration, the residual assets (2 HUMRAAMs with associated hardware and software) were provided to the Marine Corps to support their ongoing Complimentary Low Altitude Weapons System (CLAWS) program. ($ 4.872 Million)

(U) **FY 1999 Plans:**

- SAR ECCM: The hardware and software implementation of candidate SAR ECCM algorithms applicable to Sensor Emulation Platform (SEP) will commence. Selected ECCM techniques will be implemented for mitigating low-level ECM threats in both the analog (front end) and image domain portions of the radar. Additional data will be collected to support technique development. A laboratory

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demonstration of the selected ECCM products will occur. Design efforts and test planning will get underway in preparation for a proof of principle demonstration scheduled for FY 2000. ($ 7.850 Million)

- LCCMD: The noise radar seeker will be focused on the design and fabrication of a seeker in preparation for captive flight-testing. Both Preliminary Design Reviews and Critical Design Reviews will be completed for the noise seeker and the airborne test instrumentation. Fabrication of the noise radar seeker and airborne instrumentation will continue through the end of the year. The MEMS ESA risk reduction effort will be completed with final results of system trades and laboratory testing of a subarray. The four concept development efforts will be completed with final results of system trades and limited laboratory testing. The Government will select the most promising concepts based on the results of the risk reduction and concept development contracts to proceed to ground testing. ($ 14.617 Million)

- ADSAM: Modifications to the HUMRAAM developmental system will be completed. Analysis of the flight test results, comparisons to predictions and model modifications will be completed. Technical lessons learned, including software and hardware will be transferred and implemented, if possible, to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc). ($ 2.790 Million)

(U) **FY 2000 Plans:**

- SAR ECCM. The design and implementation of the selected ECCM techniques will be completed and integrated on-board the SEP test bed and an operational ISR sensor platform. A proof-of-principle demonstration will be conducted with real-time in-flight jamming and processing. ($ 9.050 Million)

- LCCMD: The noise radar seeker fabrication will be completed. The noise radar seeker will undergo extensive ground tests, be integrated into an A3 aircraft, and captive flight-testing will be initiated. Those seekers selected for ground testing will be fabricated and undergo extensive ground testing. The Government will select the most promising concepts based on the result of the ground testing contracts to proceed to captive flight and live fire testing. Design modifications to the MALD to make it suitable for an interceptor will be initiated. ($ 21.000 Million)

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- Adjunct AEW: Begin the development and fabrication of a subarray portion of a prototype composite, lightweight, integrated phased array antenna to demonstrate that the desired antenna concepts can be implemented while also achieving the design goals of low weight and cost. Mode control/interleaving algorithms will be developed. Also, the preliminary design for a means of carrying a complete radar system on a UAV, such as the Global Hawk, will commence. ($ 2.500 Million)

- MEM-tenna: Modify existing designs of MEMS X-band phase shifters and initiate prototype manufacturing. The design of a prototype ESA that will incorporate the completed MEMs phase shifters will also begin. ($ 7.800 Million)

(U) **FY 2001 Plans:**

- SAR ECCM: An operational real-time demonstration will be conducted with the modified SEP platform against a set of recognized and non-recognized ECM threats. The effectiveness of the DARPA developed ECCM techniques will be qualitatively evaluated by image analyst assessment of SAR image interpretability and quantitatively evaluated by using current state-of-the-art automatic target recognition (ATR) software. ($ 5.000 Million)

- LCCMD: The noise radar seeker captive flight test will be completed and test results will be analyzed. The Government will determine whether the noise seeker will proceed to live fire testing. The fabrication of the other seekers selected for testing will be completed and captive fight testing will be initiated. Design modifications to the MALD will be completed. ($ 20.500 Million)

- Adjunct AEW: The completed subarray will be laboratory tested. The full-scale design and integration of an airborne phased array antenna will commence. Also, the manufacture of a prototype for an external pod, or other means for carrying a final radar system, will commence. Planning for the final radar system integration and testing will begin. ($ 6.000 Million)

- MEM-tenna: Manufacture of a full-scale antenna using MEMs phase shifters will begin. A transmitter and beam controlling processor will be integrated with the array. Calibration techniques with specific and general applicability will be developed. Planning for the final integration and test planning will start. ($ 7.180 Million)

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
LCCMD:	
Apr 99	Infrared Seeker Laboratory Demonstration
Apr 99	Optically Steered ESA Antennas Laboratory Demonstration
Apr 99	UHF Antenna Laboratory Demonstration
May 99	Laser Seeker Laboratory Demonstration
Jan 00	Noise Seeker Captive Flight testing Start
Sep 00	Selected Seeker Ground Testing Start
Jun 01	Selected Seeker Captive Flight Testing Start
Sep 01	Selected Seeker Integration with Modified MALD
Mar 02	Selected Seeker Live Fire Testing Start
SAR ECCM:	
Aug 99	Laboratory ECCM Demonstration
Aug 00	Field ECCM Demonstration
Adjunct AEW:	
Nov 00	Begin development and testing of low-cost, multi-function antenna subarray and algorithms
Nov 01	Begin full scale design and fabrication of phased array antenna

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MEM-tenna:

Jul 00	Initiate prototype phase shift manufacturing
Dec 01	Complete 11,000 MEM phase shifters
Mar 02	Full scale antenna fabrication using MEMs phase shifters

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COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensor and Exploitation Systems SGT-04	85.437	84.626	101.291	90.753	104.976	92.832	92.832	92.832	Continuing	Continuing

(U) **Mission Description:**

(U) The development efforts described herein embody key sensor demonstrations and the exploitation of sensor products. These efforts, in conjunction with those described in Projects CCC-02 and SGT-02, seek to develop the systems needed to provide the warrior with situational awareness and precision targeting capability. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; and provide semi-automated recognition and precision tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program; the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); the Sensor to Shooter to Weapon (SSW); Moving and Stationary Target Acquisition and Recognition (MSTAR) program; Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Airborne Video Surveillance (AVS) program; Affordable Moving Surface Target Engagement (AMSTE) program, and the Organic GMTI Radar (OGR) program.

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under natural and artificial camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (0.1 FA/sq.km max) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR will be developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem (GCDS) is being developed to provide real time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing (ATD/C), and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended for FOPEN as well as Multi/Hyper Spectral Image (MSI/HSI) sensor input, geolocation and multi-sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN Radar on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) with other airborne sensors (e.g., the Senior Year Electro-optical Reconnaissance System (SYERS P31) on the U-2) and modes (GMTI/passive detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses will also be carried out to evaluate the capability

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for FOPEN Moving Target Identification (MTI) and Radio Frequency Intelligence (RFINT) for increasing the effectiveness of Counter CC&D on future system designs.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD will develop, test and transition to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system are automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for an enhanced system are increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. An enhanced-fielded system will further increase automatic target recognition to 30 targets.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance based on SAR. This is accomplished through fundamental and innovative technology developments, large-scale data collections, and detailed system evaluations. The approach to detect stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for those image regions of interest (ROIs) that have been selected based on their likelihood of target content. A model-driven subsystem then refines these target candidates by using a SAR signature prediction module to determine the true target ID of the target within the ROI. To handle moving targets, one-dimensional model-based analysis of radar returns from multiple viewpoints will be used to perform identification. Other program goals include: significant advances in tools including ATR tools and capabilities to efficiently perform interactive image exploitation; development of rapid target model construction; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation, and development and demonstration of ATR- and compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths. The latter uses statistical representation of the background to perform aggressive compression and wavelet-based approaches to compress detected targets to maintain signature fidelity and is referred to as "intelligent bandwidth compression."

(U) The Moving Target Exploitation (MTE) program's objective is to provide significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-valued ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques are being investigated and evaluated: the automatic tracking of ground moving vehicles; the automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; the discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI

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range profiling and 1-D automatic target recognition; and the imaging of specific moving targets via enhanced moving target imaging (MTIm) processing. Specific applications are targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk platforms. In addition, system-level approaches for the application of complex-data techniques will be investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from manned reconnaissance aircraft and Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): the real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery using precision geo-referenced orthomosaics as reference imagery; Activity Monitoring (AM): the reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): the simultaneous tracking of multiple ground vehicles (up to 12 targets)in the sensor platform area of regard but outside a single sensor field of view.

(U) The goal of the Affordable Moving Surface Target Engagement (AMSTE) program is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land and sea based). The use of netted ground moving target indication (GMTI) sensors will be explored using existing and planned sensors to produce a precision ground moving target fire control solution. Integrated weapons system architectures will be evaluated and demonstrated which include netted air-to-ground GMTI sensors; fighter-based weapons, long range precision weapons, and gun launched weapons. In-flight midcourse and terminal guidance to weapons will also be explored to drive weapon system CEP's an order of magnitude below current systems against moving targets. The precise cueing from the netted GMTI sensors will allow for lower cost weapons by reducing the complexity of, or eliminating entirely, the weapon's terminal guidance seekers. Additionally, collateral damage will be minimized by virtue of the very precise targeting and midcourse/terminal phase flight updates. The AMSTE program will begin with a thorough characterization of GMTI sensor fire control feasibility including advanced multi-sensor tracking and association algorithms, Space Time Adaptive Processing (STAP) to reduce sensor minimum detectable velocity and multi-sensor data collection/analysis to verify fire control accuracy predictions. Communications and weapons system studies will also be conducted to minimize weapon cost.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technology to enable a low cost capability for the detection and tracking of moving vehicles and personnel, through foliage, using "organic" assets for Army or Marine units. The goal is to detect vehicles at ranges

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of 10 – 20 km and personnel at ranges out to 10 km with low false alarm rates. The concept is based on the use of separate transmitters and receivers, each of which is designed for low cost and portability. False alarms and tracking will be achieved through the creation of multiple narrow azimuth receive beams using high-speed digital beam forming computers. To ensure adequate foliage penetration, the system will be designed to operate in the VHF-UHF frequency regime. The ultra-miniature receivers located at each receive antenna array will be connected to the central signal processor via fiber optic links for ease of setup and to provide for the reduced cost and weight of the overall system. The use of commercial HDTV broadcasts, as a potential source of illumination energy will also be evaluated in this effort.

(U) The goal of the Congressionally-mandated Geographic Synthetic Aperture Radar (GeoSAR) Program is to develop and test an airborne, radar-based foliage penetration/terrain feature mapping and geographic information system with an emphasis on both defense and civil applications. This program will be completed with FY 1998 funding and transitioned to Army Topographical Engineering Center in early FY 2000 for user validation.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- The Counter CC&D Program's Foliage Penetration (FOPEN) SAR completed Critical Design Review (CDR) for test and evaluation on a manned platform which will provide inputs via narrowband tactical data links to the image exploitation capabilities in a dedicated Ground Control and Display Subsystem (GCDS). The Image Exploitation techniques developed under SAIP have been extended to include unique characteristics of VHF/UHF band FOPEN radar, high spatial resolution U2 SYERS MSI sensor, multisensor image registration and geo-location and object correlation to improve the reliability of detection and discrimination of tactical targets under camouflage and foliage cover. Data from the FY97 Keystone97 Counter CC&D exercises have been processed to verify FOPEN SAR's ability to reliably detect tactical targets, georegistration of SAR with MSI and X-Band imagery, and show feasibility of meeting ADT/C objectives of 0.1 False Alarm per square kilometer. A feasibility study was carried out for adding FOPEN MTI and RFINT within the FOPEN architecture. Automated spectral exploitation processing techniques were implemented in an integrated software environment using data from the FY97 Dixie MSI collection. ($ 21.000 Million)

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- The GeoSAR Program completed the development of the foliage penetration, mapping radar and integrated it on a contractor-furnished aircraft. The Image Formation Processor and Geographic Information System have been baselined in preparation for user validation flight tests. ($ 10.010 Million)

- Semi-Automated IMINT Processing (SAIP) integration and field-testing continued towards transition system objectives with initial operational deployment of the enhanced SAIP system. Formal military utility assessment was conducted with Army and Air Force operational users under US Atlantic Command (USACOM) sponsorship. System assessment was conducted by a team from USACOM and the National Imagery and Mapping Agency. Enhanced SAIP capabilities were provided to support the Global Hawk UAV SAR, the U-2 ASARS-2, and the U-2 SYERS sensor. ($ 23.894 Million)

- The MSTAR target recognition system matured into a system that was capable of identifying 20 different target types while having the ability to handle realistic target imagery under a variety of operating conditions, including target articulations and obscurations. During FY98 the system MSTAR program developed, used, and disseminated a large database of target and clutter imagery. The Electronic systems Center (ESC) and the Aeronautical Systems Center (ASC) have roadmapped the intelligent bandwidth compression technology for transition to JSTARS and ASARS Improvement Program. Full prototypes for the interactive exploitation of two different image analyst missions were also developed and evaluated. A rapid target insertion prototype system was built and evaluated, creating 5 target models and rapid ATR training systems as baseline. Resource management of the target recognition search process was prototyped and evaluated. An integrated, real-time demonstration of intelligent bandwidth compression using U2 and Global Hawk (utilizing the Sensor Emulation Platform) in support of potential SAIP or MSTAR exploitation was conducted. ($ 15.547 Million)

- The MTE program demonstrated real-time operational MTE performance against high-value moving targets by integrating the classification component and simulation testbeds developed in FY 1997 into a single MTE system testbed and flown onboard the Joint STARs T3 testbed. The MTE program successfully tracked and identified a high value moving surface target during the AF EFX98 experimental exercise. In parallel, more extensive tools have been developed, and exercised and evaluated in a ground station simulation testbed. A ground station simulation testbed has emulated the MTE data that will be available from the Global Hawk platform. Two advanced techniques, scatterer-specific imaging (SSI) and coherent change detection (CoCD) have been adapted to operate with the X-band class of radar sensors. Performance analyses for the robustness of the coherence-based techniques with X-band sensors were completed and analyses for the benefit of using these techniques to aid GMTI tracking have begun. Finally, an initial analysis and

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simulation was conducted (leveraging the GMTI tracking knowledge and tools developed under the MTE program) that illustrated the feasibility of using GMTI radars as netted fire control radars to provide precision targeting against surface moving vehicles. ($ 14.986 Million)

(U) **FY 1999 Plans:**

- The Counter CC&D Program will complete integration of a FOPEN SAR Manned Airborne Demonstrator with a tactical data link and a Ground Control and Display System to verify Global Hawk HAE UAV performance goals. A laboratory demonstration of the Multisensor Exploitation Testbed (MSET) will be conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI Exploitation and Counter CC&D Tests. Advanced FOPEN and MSI/HSI ATD/C algorithms will be extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. Analysis of FOPEN MTI/RFINT system concepts will be combined with a FOPEN/SIGINT data collection to verify concepts and verify attenuation models at shallow angles. ($ 33.523 Million)

- The SAIP Operational Assessment will be completed and the final transition configuration of system stood up. Demonstration of all software upgrades will be conducted. Interim operational capabilities will be transitioned for integration into the US Air Force flight test facility and to the Army ETRAC system. ($ 13.609 Million)

- The evaluation of the 20 target MSTAR system with full extended operating condition (EOC) will be expanded using the new data collections, including Global Hawk data acquired through the sensor emulation Platform (SEP). Scalability of the MSTAR system will be demonstrated by extension to a 25-target capability. MSTAR based technologies will be integrated with SAIP and STARLOS technology and transition to a real time demonstration system will begin. Also, a three-year effort to develop an MSTAR model-driven ATR system will begin to accommodate moving targets using MTE technology. Multiple modes of radar processing (high range Resolution, Inverse SAR, phase history) shall be utilized to improve performance on moving and stationary targets. Development and evaluation of rapid target insertion and interactive exploitation systems will continue, with key milestones occurring in FY 2000. ($ 21.494 Million)

- The MTE Program will demonstrate and evaluate the effectiveness of MTE on-board the JSTARs T3 Testbed against a complex set of military vehicles. The SEP testbed will be completed and GMTI data will be collected and used to validate a synthetic SEP data generator. The first build of the MTE-CGS ground station will be completed and demonstrated using synthetic SEP data. Additional

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studies and analyses will develop and assess the technology to support affordable, precise, moving surface target engagement. Weapon system trade studies will be conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, BM/C3 requirements, and low cost sensor to weapon link designs. Multi-platform automated GMTI precision association and tracking algorithms will be developed and exercised using data collecting by employing existing GMTI sensors in a coordinated simultaneous collection architecture. ($ 16.000 Million)

(U) **FY 2000 Plans:**

- Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000. ($ 4.532 Million)

- The MSTAR system will become the ALL-STAR system (ALL-Situation Taskable ATR for Radar), has the goal of an ATR system capable of dealing with both moving and stationary targets using a common reasoning system. The All-STAR program, which is based on the MSTAR technologies, will be able to identify 30 different target types, where the targets can be operating under varying conditions, including motion, background, articulation, obscuration, configuration, and target manufacturing variations. Incorporating technology from the SAIP program to analyze force structure and make use of context, false alarm rates on newly collected clutter data representative of operational challenges will drop to one per 200 square kilometers. Using distributed parallel computing, a near time system will demonstrate recognition capabilities of stationary targets. Also, a toolkit of interactive exploitation tools integrated with commercial technology will provide operationally useful ATR capabilities to image analysts. The rapid target model insertion project will demonstrate the ability to incorporate a new target model into the All-STAR system within two weeks, representing a five-fold improvement over 1997 MSTAR baseline rates. ($ 18.521 Million)

- The AVS program will integrate, demonstrate and evaluate airborne and laboratory systems in a simulated military mission with these technology goals: Activity Monitoring - upgrade to monitor activities (e.g. soldier movement, tactical and strategic vehicle movement) in larger areas and along extended lines of communication; Moving Target Surveillance - demonstrate increased reliability of 3 target tracking/reacquisition and scaled development to track 6 targets; Precision Video Registration - Demonstrate 2 meter RMS error geolocation accuracy on 80% of mission imagery similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). ($ 10.289 Million)

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- The Counter CC&D Program will complete verification of FOPEN SAR imaging and target detection on the Army RC-12 Airborne Demonstrator. Real time surveillance will be demonstrated via a tactical data link and a Ground Control and Display System. A series of tactical demonstrations will be conducted with Army and Air Force exercises to validate the operational utility of the FOPEN SAR. The Multi Sensor Exploitation Testbed will be utilized to project Counter CC&D Exploitation capabilities in a CIGSS compliant architecture. Concept Development studies and preliminary data collection experiments will be completed for FOPEN MTI/RFINT. ($ 31.200 Million)

- The Affordable Moving Surface Target Engagement (AMSTE) Program will leverage the exploratory work for precise engagement of moving surface targets that was begun under the MTE program. The weapon system trade study and initial non-real-time precision fire control tracking experiments will be completed. Multisensor registration, association and tracking algorithms will continue to be developed, and iterative experimentation will be conducted. The design work to support real-time networked precision fire control experiments will begin; the goal is to support at least two competing AMSTE contractors throughout the experimentation. Critical enabling technologies will begin development including, but not limited to, low cost weapon data links, automated endgame BMC3 sensor control algorithms/software, etc. ($ 25.000 Million)

- The Organic GMTI Radar (OGR) program will build upon technologies developed under the Counter CCD program to initiate the fabrication of a low-cost full-scale receive array and complete the fabrication of the radar signal processor, beam forming computer, and solid state transmitter. Planning for full scale testing and evaluation will begin. ($ 11.749 Million)

(U) **FY 2001 Plans:**

- The All-STAR system will deal with a hundred different target types, using targets generated with the efficiencies afforded by the Rapid Target Model Insertion developments. The emphasis will be on maintaining an ability to treat targets under realistic conditions, and to be able to incorporate algorithmic methods that permit the tasking of collection assets to maximally improve recognition capabilities (Active ATR). For moving targets, the recognition capabilities developed in the ALL-Star project will be integrated with tracking capabilities developed elsewhere to improve recognition rates based on multiple views. Recognition capabilities will be able to fuse radar information from targets while they are moving as well as information acquired when they are stationary. To image moving targets, inverse SAR methods (ISAR) will be investigated to integrate with other information to improve recognition and decrease false alarms. ($ 8.000 Million)

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- The AVS program will integrate, demonstrate and evaluate airborne systems in simulated military missions with these technology goals: Activity Monitoring - increased reliability and coverage for point, area and LOC monitoring; Moving Target Surveillance: Demonstrate tracking/reacquisition of 12 targets; Demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. ($ 8.000 Million)

- The Counter CC&D Program will complete development of concepts of operation, and hold Readiness Review and Test and Evaluation review for Demonstration #3, FOPEN image interpretation with MSET at 60 sq km per minute at 40 km range, and demonstrate operational detection of user-specified threats at .01 FA per sq km. ($ 19.753 Million)

- The Affordable Moving Surface Target Engagement (AMSTE) Program will continue the development of critical networked precision fire control GMTI tracking technologies. The detailed design and modification of existing system components will be completed to support multiple real-time precision fire control tracking experiments; the required sensor, data link, processor, BMC3 infrastructure, and target ground truthing modifications will be made. Additional subsystem modifications will continue to support subsequent AMSTE weapon system experimentation, including weapon modifications. If required, additional multiple platform GMTI data collections to support advanced GMTI precision fire control tracking will be conducted. ($ 37.000 Million)

- The Organic GMTI Radar (OGR) program will complete the fabrication of the receive array and software required for laboratory and field-testing. Hardware and software will undergo laboratory acceptance testing and field experimentation will begin. Experiments will occur at multiple sites using bistatic modes with dedicated transmitters and transmitters of opportunity. Initial ROC curves will be developed and multistatic phenomenology will be verified. ($ 18.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Mar 99	Start MSET SYSTEMS Integration.

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Apr 99	MTE weapon system trade studies and precision fire control tracking studies initiate.
Apr 99	Airborne MTE demonstration with Joint STARS.
May 99	FOPEN MTI/RFINT collection at Ft Gordon on Army Moving Targets.
Jul 99	Complete integration of SAIP transition configuration.
Jul 99	GeoSAR foliage penetration interferometric mapping validated.
Aug 99	MTE Multiple platform GMTI data collection.
Sep 99	Non-real-time precision fire control laboratory experiment
Sep 99	Flight demonstration of FOPEN radar on manned platform.
Nov 99	GeoSAR transition to user completed.
Nov 99	Final MSTAR ATR demo: 25 targets, full range of EOC's, integration with interactive exploitation tools, SEP data.
Jan 00	Initial Delivery of MSET MSI/SAR Integrated Tools
Mar 00	AMSTE weapon system trade studies concluded
May 00	Verification of FOPEN SAR Automatic Target Detection and Cueing.
May 00	FOPEN MTI/RFINT Concept Development Studies complete.
May 00	AMSTE multi-platform data collection.
Jun 00	Completion of "brassboard" OGR receive antenna
Jun 00	Airborne demonstration of Airborne Video surveillance technologies.
Jul 00	Delivery of Refined MSET MSI/HIS/SAR Integrated Tools
Jul 00	Participate in Army Warfighting Experiment.
Sep 00	AMSTE laboratory precision fire control experiment completed
Sep 00	CARABAS Testing Effort Joint US Campaign
Nov 00	All-STAR demonstration of 30 different target types using full operational conditions and significant reduction in false alarm rates.
Jul 01	Near Real-Time Implementation of MSET MSI/HIS/SAR Integrated Tools
Sep 01	AMSTE real-time precision fire control field experiment
Nov 01	All-STAR demonstration of a system having a hundred target type capability.

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APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defense-wide
BA3 Advanced Technology Development

R-1 ITEM NOMENCLATURE
Marine Technology
PE 0603763E, R-1 #51

COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	19.597	23.659	22.538	21.964	48.396	55.896	57.696	60.496	Continuing	Continuing
Advanced Ship-Sensor Systems MRN-02	19.597	23.659	22.538	21.964	48.396	55.896	57.696	60.496	Continuing	Continuing

(U) **Mission Description:**

(U) The objective of the Marine Technology Program is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) enhancement of the ability of US naval forces to dominate the maritime battlespace, particularly in the littoral arena; 2) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle; and 3) ability to counter the threat to US personnel and platforms created by the worldwide spread of increasingly sophisticated naval technology. In particular, the growing threat of quiet diesel/electric (DE) submarines, the continuing worldwide proliferation of advanced submarine and weapons capabilities, and the easy availability of modern underwater mines all represent unique warfighting challenges encountered in the maritime arena. These threats pose the greatest challenges for operations in the restricted water, near-shore regimes that are of growing importance to US strategic considerations, and necessitate the continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral.

(U) The purpose of the Advanced Ship-Sensor Systems project is to develop innovative sensing and communication technologies that allow US naval forces to maintain and improve their effectiveness in operating forward from the sea in the ever more dangerous conditions of future tactical environments. This project has three principal thrusts: 1) generation of improved maritime battlespace awareness through the development of advanced sensors capable of more completely and robustly interrogating the surrounding environment; 2) development of advanced communications capabilities to enable expanded maritime information networking; and 3) exploration of platform system approaches for increased survivability in light of these and other advanced sensor and communications capabilities, including integrated sensor/stealth solutions.

(U) The Undersea Littoral Warfare (ULW) program is developing the Netted Search, Acquisition, and Targeting (NetSAT) System, a networked approach for improved attack performance that exploits the use of a sonobouy field during the weapon run to identify, locate, and mitigate the impact of countermeasures and target evasion tactics on torpedo operation. A bi-directional fiber optic link enables return of torpedo

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information to a processor servicing the other sensors on the network in addition to providing a command link for the weapon. The ability to rapidly discern the geographic picture from multiple viewpoints is expected to provide major (10x) torpedo performance improvements in strong countermeasure environments while requiring only modest modification of existing torpedo inventories. This development will be seamlessly coupled to the active acoustic search system development completed in FY98 (Distant Thunder), providing system significant enhancements in Anti-Submarine Warfare (ASW) performance at all points in the attack chain. In addition, the Undersea Littoral Warfare (ULW) program is conducting three other extended feasibility assessments: the ability of innovative, multi-dimensional receiver arrays, when coupled with optimal processing approaches, to provide robust passive sonar solutions in shallow water; the ability to detect non-acoustic submarine signatures from an unmanned aerial vehicle based system; and the ability of advanced synthetic aperture sonar processing techniques to revolutionize our ability to classify and identify underwater mines at much greater search rates than possible with current systems.

(U) The Water Hammer program is conducting concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi). Water Hammer has the potential for rapid, precision, in-stride lane clearance in deep or shallow water, reducing the need for high fidelity detection and classification. While the initial program focuses on mine/obstacle clearance, Water Hammer also has general utility as a close-in defense system for ships against multiple classes of subsurface threats.

(U) The Buoyant Cable Array Antenna (BCAA) program is investigating a full duplex link (transmit and receive) for data transfer and communications to/from submarines while operating at speed and depth. Technologies that may be employed to achieve high data transfer rates from a submerged condition include photonic signal and power links, enhanced antenna loading materials, adaptive array calibration, and enhanced communications protocols.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Continued development, planning, and testing of the proof-of-concept Anti-Submarine Warfare (ASW) Netted Search, Acquisition and Targeting (NetSAT) system at sea, incorporating a wide frequency band, autonomous, long duration, leave behind acoustic source; signal processing for enhanced detection and attack performance (Distant Thunder); and acoustic space-time adaptive processing. ($ 10.628 Million)

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- Conducted development of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification. ($ 1.300 Million)
- Within the context of Congressionally directed efforts in Smart Anti-Submarine Warfare (ASW) and Sonar Space-Time Adaptive Processing (STAP) conducted development of smart ASW sensors to support Netted Search, Acquisition and Targeting (NetSAT); commenced feasibility investigation of Robust Passive Sonar (RPS) using space-time processing (STP) techniques; by conducting a sonar STP and shipping noise characterization experiment. ($ 3.702 Million)
- Completed initial underwater mine neutralization explosive proof-of-concept experiments, successfully proving the feasibility of generating and propagating phased array pulse energy sufficient to destroy mine-like targets; completed single non-explosive source fabrication and testing; completed 1x 4 non-explosive source array fabrication and began testing to address technology issues; initiated 4x4 non-explosive source array design. ($ 1.577 Million)
- Conducted initial technology assessments and feasibility testing of advanced submarine communication system concepts, including signal exploitation, antenna array communications, and adaptive waveform generation. ($ 1.140 Million)
- Conducted initial technology assessment and feasibility testing of advanced submarine concepts, including: hydrodynamic design, acoustic smart skins, and detection of non-acoustic signatures. ($ 1.250 Million)

(U) **FY 1999 Plans:**

- Complete initial prototype ASW NetSAT system, incorporating acoustic space-time adaptive processing; integrated weapons control with countermeasures deconfliction; and integrated weapon/sensor signal processing approaches for enhanced attack performance. Conduct prototype testing to establish the detection-to-attack performance enhancements provided by networked approaches; and perform assessment of covert autonomous sensor deployment and tagging systems. ($ 12.409 Million)
- Complete final testing of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) for mine classification; assess processing approaches for application of synthetic aperture sonar (SAS) to short sonar arrays. ($ 0.750 Million)

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- Complete feasibility investigation of Robust Passive Sonar (RPS) processing and array concepts, utilizing geographically referenced processing and space-time processing (STP) techniques. ($ 3.200 Million)

- Continue non-explosive underwater energy projection technology development for mine neutralization, including fabrication and test of 4x4 source array test article. ($ 3.526 Million)

- Conduct comparative testing of DARPA-generated multi-element buoyant cable array antenna concepts and Navy-generated single element approaches in Ultra High Frequency (UHF) bands and assess cost/performance tradeoffs; prepare for phenomenology and Global Positioning System (GPS) risk reduction, and communications link risk reduction experiments at L-band. ($ 3.774 Million)

(U) **FY 2000 Plans:**

- Update and complete development of prototype Anti-Submarine Warfare (ASW) Netted Search, Acquisition and Targeting (NetSAT) system; conduct final operational proof of concept demonstration, including an integrated detection/attack approach; coordinate transition of result to Navy. ($ 5.100 Million)

- Initiate development of synthetic aperture sonar (SAS) processing for short sonar arrays; conduct initial performance test sequence. ($ 2.200 Million)

- Complete extended feasibility investigation of the additional performance provided by external information (surface shipping positions and signatures) for the Robust Passive Sonar (RPS) processing and array concepts. ($ 3.818 Million)

- Design, fabricate, and demonstrate an underwater energy projection array prototype for at sea testing to be used to verify theoretical predictions, and to identify and address design issues in the Water Hammer concept. ($ 2.600 Million)

- Complete GPS and communications link risk reduction experiments at L-band; finalize system concept. Commence component technology development and initiate design and development of a full duplex (transmit/receive) submarine Buoyant Cable Array Antenna prototype. ($ 5.700 Million)

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- Conduct technology survey and assess system feasibility for an unmanned aerial vehicle non-acoustic submarine detection system. ($ 2.720 Million)

- Continue technology assessments and feasibility testing of advanced submarine concepts, including signature reduction, signal exploitation, autonomous sub-systems, and hydrodynamic flow control. ($ 0.400 Million)

(U) **FY 2001 Plans:**

- Complete development of synthetic aperture sonar (SAS) processing package for short sonar arrays; conduct final performance demonstration; transition to service for system implementation. ($ 2.300 Million)

- Conduct at sea testing of the Water Hammer subarray prototype. Assess implementation considerations of concept and address system issues such as platform, propulsion, sensors (if any), and concept of operations. Coordinate transition of program to Navy. ($ 2.564 Million)

- Complete design and begin fabrication of a full duplex (transmit/receive) submarine buoyant cable array antenna (BCAA) prototype; conduct algorithm and software development for spatial and temporal adaptive communications link processor. ($ 9.050 Million)

- Commence component technology development for an unmanned aerial vehicle non-acoustic submarine detection system, emphasizing transmitter and receiver size and weight reduction; develop design for initial prototype; establish baseline-processing approach and assess performance. ($ 8.050 Million)

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(U) **Program Change Summary:** *(In Millions)*

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	19.626	24.788	33.998	43.464
Current Budget	19.597	23.659	22.538	21.964

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects minor repricing and completion of the Electromagnetic Turbulence Control effort.

FY 1999 Decrease reflects minor repricing and completion of Anti-Submarine Warfare Netted Search, Acquisition and Targeting (NetSAT) effort.

FY 2000/01 Decrease reflects efforts scaling down as they near completion; transition ASW NetSAT effort to Navy; completion of Robust Passive Sonar effort; proposed new approaches for drag reduction technology shifted to BA1, in keeping with the speculative physics-based research necessary to prove the concept.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
4QFY98	Complete final demonstration of Distant Thunder Anti-Submarine Warfare (ASW) detection system in western Pacific operations areas.
4QFY98	Complete test of 2 x 2 Water Hammer source array.
1QFY99	Conduct Netted Search, Acquisition and Targeting (NetSAT) system initial engineering checkout test.
2QFY99	Conduct at sea demonstration of a prototype space-time tactical sonar processor.
2QFY99	Complete fabrication of 4 x 4 Water Hammer source array as second test article.

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3QFY99	Complete interferometric synthetic aperture sonar (IFSAS) sea test.
3QFY99	Complete quantitative feasibility assessment of geographically referenced space-time processing approach.
3QFY99	Conduct at sea receives link testing at UHF in support of Buoyant Cable Array Antenna (BCAA) concept definition.
4QFY99	Conduct initial demonstration of prototype NetSAT system (targeting and attack only) in a controlled test range environment.
4QFY99	Complete feasibility assessment of short aperture Synthetic Aperture Sonar (SAS) processing.
4QFY99	Complete test of 4 x 4 Water Hammer source array.
4QFY99	Finalize BCAA concept at Ultra High Frequency (UHF).
1QFY00	Conduct initial feasibility sea test for BCAA concept at L-band.
2QFY00	Conduct Design Review for Water Hammer subarray prototype.
3QFY00	Conduct Design Review for short aperture SAS processor development.
3QFY00	Conduct Preliminary Design Review (PDR) for BCAA prototype system.
4QFY00	Conduct final NetSAT sensor-to-shooter operational demonstration including surveillance, detection, handoff, targeting and attack in a countermeasure environment.
4QFY00	Complete Feasibility assessment for Unmanned Aerial Vehicle (UAV) based non-acoustic Anti-Submarine Warfare (ASW) sensor.
1QFY01	Conduct initial at sea performance data collection experiment for ASW sensor.
2QFY01	Demonstrate Water Hammer subarray prototype at sea.
2QFY01	Conduct Critical Design Review (CDR) for BCAA prototype system.
3QFY01	Conduct sea test of short aperture SAS processor.
4QFY01	Complete system engineering definition of a Water Hammer array prototype.
4QFY01	Complete initial off-line performance assessment of non-acoustic ASW sensor.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development						R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, R-1 #52				
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	79.319	88.613	97.825	101.376	106.677	77.000	87.000	87.000	Continuing	Continuing
Rapid Strike Force Technology LNW-01	40.304	44.991	50.223	50.176	63.177	27.000	22.000	22.000	Continuing	Continuing
Small Unit Operations LNW-02	39.015	43.622	47.602	51.200	43.500	50.000	65.000	65.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Two broad efforts are being pursued in support of this objective: Rapid Strike Force Technology and Small Unit Operations.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project are the Combat Hybrid Power Systems program that is developing and demonstrating hybrid electric power and energy management systems for future combat vehicles; the Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) program will design, develop, test and transition a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles to the Services; the Vehicle Self-Protection program will develop technologies to enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles; the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; the Mobile Tactical Operation Center program that will provide tactical commanders with current situational awareness, communications and control; the Virtual Strike program that will develop technologies for low-cost, deployable communications deception nodes to support dispersed forces.

(U) The Small Unit Operations project is developing the critical technologies that will enable dispersed units to effectively perform warfighting operations that traditionally have required massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and

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mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater, and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	80.924	108.490	93.413	89.700
Current Budget	79.319	88.613	97.825	101.376

(U) **Change Summary Explanation:**

FY 1998 Decrease reflects minor repricing and SBIR reprogramming.

FY 1999 Decrease reflects impact of congressional program and undistributed reductions and minor below threshold reprogrammings.

FY 2000/01 Increases reflect net effect of addition of Mobile Tactical Operation Center; initiation of Virtual Strike program; repricing of the Small Unit Operations program; and completion of the Combat Hybrid Power Systems Program in FY 2001.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	40.304	44.991	50.223	50.176	63.177	27.000	22.000	22.000	Continuing	Continuing

(U) **Mission Description:**

(U) The emerging US vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient, land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Combat Hybrid Power Systems (CHPS); Helicopter Active Noise and Vibration Control (HANVC); Reconnaissance, Surveillance, and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Virtual Strike; Vehicle Self-Protection (VSP); and a Mobile Tactical Operation Center (M-TOC). The CHPS, RST-V, M-TOC and TMR programs are closely coordinated with the US Army, Navy, and Marine Corps, and with DARPA's Electric Vehicle (EV-01) and Small Unit Operations (LNW-02) projects.

(U) The Combat Hybrid Power System program will develop enabling technologies and conduct demonstrations of an integrated hybrid electric power system that provides power and energy management for all of the electric subsystems throughout future combat vehicles. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The hybrid electric power system will consist of an engine/alternator, sized for average power demand, energy storage and power averaging components which provide both continuous and pulsed power, distribution networks, subsystem controls, and power conditioning devices. Vehicles of various configurations and for a variety of missions will be simulated to evaluate subsystem requirements, topologies, and military utility. The simulated vehicle concepts will demonstrate greatly reduced noise and thermal signatures; improved mobility, survivability, lethality, and fuel economy; optimized interior layouts; significantly reduced volume and weight. These advantages will result in deployable, affordable combat vehicles that meet mission requirements.

(U) The HANVC program will design, fabricate and demonstrate an Active Rotor Control (ARC) system that should achieve 10dB radiated sound pressure noise reduction, and cancel vibration and noise from the main transmission to reduce maintenance costs and improve passenger comfort.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

(U) The Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate, and transition to the Services a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension. The vehicle will also host integrated precision geolocation, communication and RST sensor subsystems. Vehicle design efforts will take into consideration, to the extent possible, related technologies evolving from DARPA's Small Unit Operations Project. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators, and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed, and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ATD as well as address Joint USMC-SOCOM requirements for the Light Strike Vehicle and TV-RSTA program and HMMWV upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components, and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with semi-intelligent, cooperating platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: perception, autonomous operation, and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90% accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction, and (b) traversal of rugged/complex terrain using 1 command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to 1 m/s over 25 cm steps and decimeter-scale rubble.

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(U) The Vehicle Self-Protection (VSP) program will develop an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) The Virtual Strike program will develop and demonstrate technologies for low cost, deployable communications deception nodes to support dispersed forces. Virtual Strike will employ situational awareness tools to locate and identify enemy and friendly forces, a network of communications spoofing devices to deceive the enemy as to the location and tempo of U.S. forces, electronic warfare techniques to mask U.S. systems or inject false targets into enemy sensor systems, and small autonomous vehicles to support the deployment and movement of the communications and electronic warfare devices. The first phase shall develop concepts for communications deception components that can be adapted to mobile or fixed host platforms.

(U) The Mobile Tactical Operation Center (M-TOC) program will enable the battalion commander to control organic surveillance assets and fire support while on the move. In addition, battlefield situational awareness will be provided by connectivity to division and/or corps operations centers. This program will develop the technology needed to allow high-performance exploitation and fusion of varied data products by the commander. Enhanced visualization and communication programs currently on-going at DARPA will be leveraged.

(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Combat Hybrid Power Systems (CHPS). ($ 17.917 Million)
  - Initiated simulation/modeling efforts using specifications for laboratory demonstration hardware to enable hardware-in-the-loop demonstration of virtual prototype.
  - Selected and procured hybrid electric power system subsystems for installation in the Systems Integration Laboratory (SIL).
  - Developed technology and initiated fabrication of selected full-scale engine/alternator, power averaging, power conditioning, and power distribution and control components.
- Helicopter Active Noise and Vibration Control (HANVC) program; Congressional addition to the FY 1998 President's Budget. ($ 4.998 Million)
  - Fabricated a Mach scale actively controlled rotor for wing tunnel testing.

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- Tested active transmission mounts on a benchtop rig.
- Conducted near full scale fixed wing testing of an actively controlled rotor.
- Conducted testing of eddy current vibration sensors.

• Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 6.565 Million)
- Successfully completed Preliminary Design and conducted Preliminary Design Review for both RST-V contractors.
- Conducted critical item demonstrations of hybrid electric power system, mobility subsystems, and survivability suites.
- Evaluated emerging technologies for vehicle survivability, tactical sensing and visualization.

• Tactical Mobile Robotics (TMR). ($ 10.824 Million)
- Developed advanced employment concepts for Tactical Mobile Robots.
- Refined program plan to incorporate emerging user requirements and more challenging mission profiles.
- Developed basic tele-operated stair climbing platform to support development of advanced multi-input mapping capabilities.
- Conducted assessment of embedded software systems to perform autonomous tactical decision-making.

(U) **<u>FY1999 Plans:</u>**

• Combat Hybrid Power Systems (CHPS). ($ 17.073 Million)
- Install and integrate hybrid electric power components in the Systems Integration Laboratory (SIL).
- Conduct tests that demonstrate simultaneous operation of pulsed and continuous loads in the laboratory and verify the virtual prototype models.
- Complete design and initiate fabrication of advanced, high risk power system components – critical enabling technologies.
- Demonstrate hardware-in-the-loop future combat vehicle virtual prototype to support technology development.

• Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 6.293 Million)
- Complete Critical Design and conduct Critical Design Review of both RST-V team designs.

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- Down select to one contractor.
- Finalize design and conduct Fabrication Readiness Review.
- Refine development of automotive subsystems.
- Evaluate emerging technologies for high data rate covert communications.

• Tactical Mobile Robotics (TMR). ($ 17.625 Million)
- Refine advanced employment concepts to exploit portable robot potential and accommodate expanded user interest.
- Demonstrate breadboard robot perception, autonomy, and obstacle negotiation (stair climbing) in challenging mission scenarios.
- Complete and evaluate competing designs for integrated robotic system.
- Refine system design and employment plans to exploit progress made with enabling technologies and accommodate multiple collaborating platform employment where practical.
- Evaluate advanced communication and control techniques.

• Vehicle Self-Protection Program (VSP). ($ 4.000 Million)
- Initiate development of an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) **FY 2000 Plans:**

• Combat Hybrid Power Systems (CHPS). ($ 8.819 Million)
- Install the completed, advanced, high-risk hybrid electric power system components in the Systems Integration Laboratory (SIL).
- Continue test and evaluation of integrated hybrid electric power system and subsystems.
- Initiate transition of Combat Hybrid Power Systems (CHPS) program to U.S. Army.

• Vehicle Self-Protection Program (VSP). ($ 5.886 Million)
- Demonstrate low defect epitaxial material compatible for photodetectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).

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- Virtual Strike. ($ 2.000 Million)
  - Develop a system concept, define system architecture, and estimate performance against threats. Build a brassboard counter communications prototype and bench test against Small Unit Operations (SUO) radio equipment. Determine optimum deployment methods.

- Mobile Tactical Operations Center (M-TOC). ($ 7.000 Million)
  - Initiate development of decision aids.
  - Assess performance of advanced display technologies in moving platform.
  - Develop requirements for connectivity, exploitation, and interface protocols.
  - Initiate development of a lightweight phased array antenna to be incorporated into the vehicle.

- Tactical Mobile Robotics (TMR). ($ 15.719 Million)
  - Initiate development of fully functional tactical robotic platforms.
  - Integrate enabling technologies into functional platforms.
  - Refine demonstration and transition plans commensurate with success in system design and multi-platform collaboration.

- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 9.799 Million)
  - Perform wheelmotor qualification tests.
  - Roll out vehicles 1 and 2.

- Advanced Concepts Evaluation ($ 1.000 Million)
  - Conduct technology assessment and feasibility testing of advanced rapid strike force concepts including precision guided munitions, force-on-force modeling, covert autonomous sensors, and future unmanned vehicle systems.

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(U) **FY 2001 Plans:**

- Combat Hybrid Power Systems (CHPS). ($ 5.676 Million)
  - Complete test and evaluation of fully integrated hybrid electric power system and subsystems.
  - Complete test and evaluation of advanced, high-risk hybrid electric power system components in a laboratory demonstration.
  - Transition CHPS program to U.S. Army.

- Vehicle Self-Protection Program (VSP). ($ 4.000 Million)
  - Demonstrate solar-blind detector array with 128 x 128 pixels.

- Mobile Tactical Operations Center (M-TOC). ($ 16.000 Million)
  - Continue phased array antenna for low radar cross-section communication.
  - Integrate advanced displays into test vehicle.
  - Continue development of decision aids.

- Virtual Strike. ($ 5.000 Million)
  - Integrate equipment into platform, build three to five integrated systems, and conduct proof of concept field test in conjunction with SUO field tests.

- Tactical Mobile Robotics (TMR). ($ 13.000 Million)
  - Complete integrated robotic system development and testing.
  - Conduct operational demonstrations with integrated systems.
  - Initiate transition to military departments.

- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 6.500 Million)
  - Deliver vehicles 1 & 2 for participation in United States Marine Corps (USMC) Advanced Warfighting Experiment.

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(U) **Other Program Funding Summary Cost:**

	FY1998	FY1999	FY2000	FY2001
PE 0603640M Marine Corps Advanced Technology	2.7	2.8	3.0	2.7
PE 0603005A Combat Vehicle and Automotive Advanced Technology	1.0	5.0	3.0	

(U) **Schedule Profile:**

Plan	Milestones
Jun 99	Demonstrate hardware-in-the-loop virtual prototype of combat hybrid power system (CHPS).
Jun 99	Conduct interim technology demonstrations in robotic perception, autonomous navigation, and locomotion on surrogate vehicles and complete breadboards for selected TMR platforms (TMR).
Aug 99	Complete Concept of Operations for Battalion level command and control center (Mobile Tactical Operation Center (M-TOC))
Sep 99	Define system design for selected platforms (TMR).
Dec 99	Electric drive checkout (RST-V).
Jan 00	Conduct Preliminary Design Review. (PDR) of selected TMR platforms and begin fabrication of same (TMR).
Jan 00	Initiate designs for decision aids and communication systems (M-TOC).
Jul 00	Integrate advanced components and demonstrate fully integrated combat hybrid power system laboratory (CHPS).
Jun 00	Vehicle 2 rollout (RST-V).
Jun 00	Complete assessment of human performance degradation due to motion (M-TOC).
Jul 00	Conduct final technology demonstration and Critical Design Review (CDR) for selected TMR platforms (TMR).
Jul 00	Define communication deception node system architecture.
Sep 00	Conduct Preliminary Design Review (PDR) for low radar cross section antenna and decision aids (M-TOC).
Oct 00	Deliver vehicles 1 & 2 (RST-V).
Jan 01	Demonstrate RST-V system capabilities in Advanced Warfighting Experiment (AWE). (RST-V).
Mar 01	Configure system for Service transition (Combat Hybrid Power System (CHPS)).
Mar 01	Demonstrate Avalanche Photodetector (APD) array with 100 amps/watt responsity and low dark current.

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Mar 01	Conduct Critical Design Review (CDR) for low radar cross section antenna and decision aids. (Mobile Tactical Operation Center (M-TOC)).
Jun 01	Integrated Survivability demonstration of Reconnaissance, Surveillance, and Targeting Vehicle (RST-V).
Jul 01	Complete design of selected communications deception node components.
Jul 01	Complete operational demonstrations of Tactical Mobile Robotic (TMR) systems. Initiate transition and technology transfer plans (TMR).

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Small Unit OperationsLNW-02	39.015	43.622	47.602	51.200	43.500	50.000	65.000	65.000	Continuing	Continuing

(U) Mission Description:

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire, and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threat is located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk, and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technology is poorly configured to operate in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and is not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Small Unit Operations Program is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that "glue" the components together, operates in any environment, is covert and is resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02

(U) The Situation Awareness System (SAS) will integrate these technologies into a 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The DARPA module will be interoperable with the Army Land Warrior equipment and provide much greater functionality at significantly less weight. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. The Geolocation Technology Program will develop and demonstrate precision miniature clocks, a low-power Global Positioning System (GPS) receiver/processor (2 joules per fix) and a digital LORAN receiver to provide the accurate navigation and targeting needed for small unit operations.

(U) The Situation Awareness System (SAS) program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested, and mountainous terrain. It will also acquire and codify knowledge of dispersed land forces tactics to develop decision aids and evaluate the utility of the aids for small units. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the Situation Awareness System functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises, to provide independent validation of the SAS functionality.

(U) The Tactical Sensors program will develop new sensor system technologies that will provide the warfighter with a capability to detect, track, and classify mobile tactical targets and to characterize fixed, man-made structures. These sensor systems provide a local, in-situ sensing capability near high value targets or at choke points in denied areas. Information provided by these sensors can be fused with other longer range space, airborne, and ground sensor systems to enhance the aggregate surveillance and tracking capabilities of US forces. Applications include surveillance, cueing, precision targeting, intelligence, and battle damage assessment with respect to time critical, mobile targets (vehicles and humans) and to fixed, man-made structures (surface and underground facilities).

(U) The Laser Acoustic Sensors program will develop a completely new class of laser acoustic sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, classification, cueing, and bomb damage assessments at distances 10X greater than current capabilities. The acoustic sensor will use a virtual acoustic array generated by angle scanning and range gating a laser beam in the atmosphere. Natural aerosols in the virtual array are displaced by the acoustic pressure wave generated by the target, and thus provide a phase modulated backscatter of the laser energy that is detectable by the receiver. A recent breakthrough in defining atmospheric turbulence cells with unique, fine structure doppler spectrum permits visibility and access to the target acoustic signature sideband structure.

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(U) **Program Accomplishments and Plans:**

(U) **FY 1998 Accomplishments:**

- Conducted field experiment of geolocation integrated brassboard system for restricted environment geolocation. ($ 3.100 Million)
- Conducted demonstration of unique time difference of arrival breadboard for 3-meter indoor geolocation accuracy. ($ 0.300 Million)
- Assessed advanced concepts and technologies for dispersed land forces applications. ($ 2.200 Million)
- Conducted field experiments and demonstrated technologies at CINC and Warfighter exercises. ($ 4.456 Million)
- Continued development of situation awareness technologies focusing on plan execution and user interface functionality. ($ 1.500 Million)
- Continued development of tactical communications capability. ($ 4.159 Million)
- Developed and demonstrated Situation Awareness System detailed design. ($ 12.100 Million)
- Continued development of internetted remote control sensors to detect, localize and characterize targets. ($ 2.500 Million)
- Continued development of surveillance and targeting sensors systems for dispersed operations. ($ 8.700 Million)

(U) **FY 1999 Plans:**

- Assess advanced concepts and technologies for dispersed land forces applications. ($ 1.100 Million)
- Conduct field experiments and demonstrate technologies at CINC and Warfighter exercises. ($ 3.188 Million)

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- Complete developments for the situation awareness and real time tasking and control technologies. ($ 1.700 Million)
- Complete technology development for tactical communications capability. ($ 2.251 Million)
- Complete evaluation of enabling technologies associated with Situation Awareness System (SAS) design and conduct breadboard demonstration of critical communications and geolocation technologies. ($ 5.000 Million)
- Complete detailed design of SAS and begin development of Situation Awareness brassboard system. ($ 14.900 Million)
- Continue development of internetted remote control sensors to detect, localize and characterize targets. ($ 4.829 Million)
- Continue development of surveillance and targeting sensors systems for dispersed operations, including laser acoustic sensor phenomenology modeling and breadboard design. ($ 10.654 Million)

(U) **FY 2000 Plans:**

- Complete SAS detailed hardware and software design. ($ 12.650 Million)
  - Complete development of the Individual Warfighter Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile, and Relay/Router/Beacon detailed hardware design.
  - Complete design of software modules for IWSAS, WTA-Base, WTA-Mobile, Relays, and network protocols.
- Complete Individual Warfighter/Warfighter Tactical Associate software coding. ($ 6.100 Million)
  - Complete IWSAS, WTA-Base, WTA-Mobile, Relays, and network code development and testing.
  - Complete situation awareness (planning, tasking, sensor control, navigation, and alerts) application software coding and testing.
- Complete brassboard fabrication of the major SAS elements (IWSAS, WTA, and Relays). ($ 1.600 Million)
- Complete development of sensor and weapon simulants for field tests. ($ 1.000 Million)

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- Integrate and perform in-house engineering tests on brassboard SAS. ($ 1.000 Million)
- Conduct performance assessment of Situation Awareness System (SAS) Phase 3 brassboard design. ($ 7.900 Million)
  - Verify that Individual Warfighting Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective.
  - Measure SAS network capacity, loading factors, data rates, and protocol performance.
  - Verify geolocation accuracy and navigation performance in urban and field environments.
  - Assess situation awareness display functionality and human – machine interface utility.
- Develop preliminary detailed demonstration plan for FY 2001 SAS operational demonstration. ($ 1.000 Million)
- Continue assessment of advanced concepts and technologies for dispersed land forces applications. ($ 0.800 Million)
- Begin fabrication of 100 Individual Warfighting Situation Awareness System (IWSAS), 10 Warfighter Tactical Associate (WTA) Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relays. ($ 5.753 Million)
- Continue development of internetted remote control sensors to detect, localize and characterize targets; continue development of surveillance and targeting sensors systems for dispersed operations. ($ 6.859 Million)
- Continue laser acoustic breadboard sensor and initiate brassboard development. ($ 2.940 Million)

(U) **FY 2001 Plans:**

- Complete fabrication of 100 IWSAS, 10 WTA-Mobiles, 1 WTA-Base, 100 tactical sensors, and 50 tactical relays. ($ 16.000 Million)
- Integrate IWSAS, WTA-Mobile, and WTA-Base with external legacy communications, data, and sensor equipment. ($ 8.800 Million)
- Test integrated Situation Awareness System (SAS). ($ 3.500 Million)

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- Conduct performance assessment of final Situational Awareness System (SAS) Phase 3 design; Measure Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99% service availability objective. ($ 8.500 Million)
- Complete development of detailed demonstration scenarios to test and evaluate performance of the Situation Awareness System (SAS) under operational conditions; perform setup of SAS field demo. ($ 2.000 Million)
- Develop training materials and conduct soldier training for field demo. ($ 1.400 Million)
- Continue development of internetted remote control sensors to detect, localize and characterize targets and continue development of surveillance and targeting sensors systems for dispersed operations. ($ 8.000 Million)
- Complete laser acoustic brassboard and initiate 2D fieldable sensor development. ($ 3.000 Million)

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
May 99	Conduct Situation Awareness System (SAS) critical technology proof-of-concept demonstrations.
Jun 99	Situation Awareness System Requirements Review.
Jul 99	Demonstrate real time mini-imaging.
Jul 99	Brassboard testing and evaluation of internetted micro unattended ground sensor system.
Aug 99	Brassboard demonstration of broadband targeting sight.
Aug 99	Demonstrate integrated sensors, tasking and control brassboard.
Nov 99	Demonstrate brassboard Situation Awareness System network design.
Dec 99	Demonstrate laser acoustic signal processing and wind tests.

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Feb 00	Complete Situational Awareness System (SAS) Critical Design Review.
May 00	Demonstrate Miniature Infrared Camera (MIRC).
May 00	Complete Situational Awareness System (SAS) software coding.
Jun 00	Complete SAS sensor and weapon simulant.
Jul 00	Complete brassboard SAS integration and test.
Aug 00	Demonstrate brassboard integrated micro-Unattended Ground Sensors (UGS) system.
Sep 00	Demonstrate laser acoustic final breadboard.
Mar 01	SAS components fabricated.
Mar 01	Complete detailed field demonstration plan.
Jun 01	Conduct demonstration readiness review.
Sep 01	Demonstrate laser acoustic final brassboard.
Sep 01	Complete micro-Unattended Ground Sensors (UGS) field demonstration tests.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support					R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, R-1 #121					
COST *(In Millions)*	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	35.633	38.498	31.387	32.632	33.944	35.373	36.634	36.922	Continuing	Continuing
Management Headquarters MH-01	35.633	38.498	31.387	32.632	33.944	35.373	36.634	36.922	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the military services for administrative support costs associated with contracts undertaken on the agency's behalf.

(U) Program Accomplishments and Plans:

(U) FY 1998 Accomplishments:

- Funding under this program element supported management and administration for the RDT&E programs assigned to DARPA. The majority of the funds were required for the pay of personnel who operate the Agency. The funding level reflects rental costs associated with the renegotiations of leases, and the related support and security requirements. ($ 35.633 Million)

(U) FY 1999 Plans:

- DARPA will continue to fund management and administrative support costs. The growth in Management Headquarters is due to increased salary requirements to accommodate mandated pay raises and an increased reliance on Intergovernmental Personnel Act appointments for program management rather than civilians. ($ 38.498 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E

(U) **FY 2000 Plans:**

- DARPA will continue to fund management and administrative support costs with two significant differences. First, the salary requirements for Intergovernmental Personal Act appointments have been budgeted within program funds in lieu of being centrally funded in this program element. This change reflects an OMB decision to treat IPAs as a support function rather than as a direct hire. Second, the additional salary requirements associated with DARPA's expanded hiring authority partially offset the IPA salary transfer. This authority was provided in the FY 1999 Authorization Act. ($ 31.387 Million)

(U) **FY 2001 Plans:**

- DARPA will continue to fund management and administrative support costs. Increased costs reflect the cost of mandated pay raises, and related security requirements. ($ 32.632 Million)

(U) **Program Change Summary:** (*In Millions*)

	FY1998	FY 1999	FY 2000	FY 2001
Previous President's Budget	35.039	38.611	42.603	43.782
Current Budget	35.633	38.498	31.387	32.632

(U) **Change Summary Explanation:**

FY 1998	Increase reflects initial below threshold reprogramming adjustments to meet infrastructure contract requirements.
FY 1999	Decrease reflects Agency repricing of support infrastructure and IPA costs.
FY 2000/01	Decreases reflect removing IPA costs from management headquarters program element, partially offset by the increased salary requirements of the expanded hiring authority.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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